SCIENTIFIC AMERICAN SUPPLEMENT No. 476

Scientific American Supplement, Vol. XIX., No. 476. Scientific American, established 1845.

NEW YORK, FEBRUARY 14, 1885.

Scientific American Supplement, $5 a year. Scientific American and Supplement, $7 a year.

THE AMERICAN DREDGERS ON THE PANAMA CANAL.

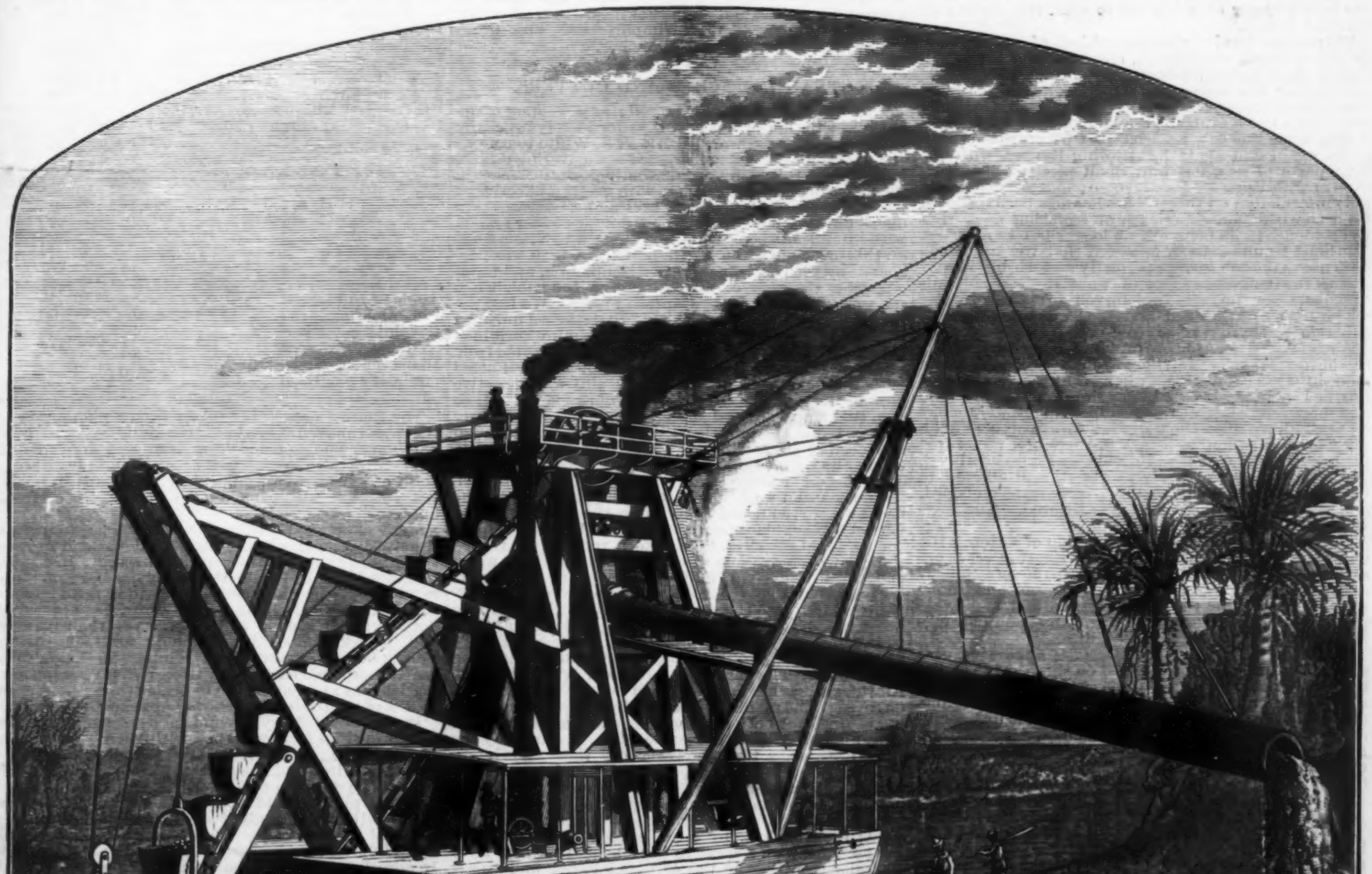
OUR engraving represents one of the great dredgers now in use on the Panama Canal. The contract for the ten miles of marsh work, beginning near Aspinwall, was taken by Slaven Brothers, this city; the great machine is believed to be the most effective of anything in the same line. It was built under the patents of Messrs. H. B. Angell and H. H. Lynch. The machinery of the dredge is mounted on a scow one hundred feet long, sixty feet wide, and twelve feet deep. There are eight engines, arranged in four pairs, for operating the machinery. The main engines are for driving the buckets which do the digging, and are of 250 horse power, having Myers' adjustable cut-off. The belt from the engine runs to the top of the bucket tower to a pulley eight feet in diameter, which drives compound driving gear, connected with the upper tumbler shaft, which is ten inches in diameter. This shaft moves a thirty-six inch square drum, over which the buckets pass when they dump their load into the hopper. The bucket tower is forty-five feet high above deck. There are thirty-eight buckets, with a capacity of one and a half cubic yards each. From sixteen to eighteen buckets full of dirt per minute are discharged into a hopper attached to a cast iron elbow near the top of the tower. This elbow is five feet four inches in diameter where it connects with the hopper, and thirty-six inches in diameter where it connects at the lower end to the discharge pipe, which is attached to the elbow. This pipe is made of boiler iron and is one hundred and fifty feet long. The distance the mud falls, the position in which it strikes, and the inclination of the discharge pipe give the mud a velocity of from 1,300 to 2,000 feet per minute through the pipe, according to the kind of material which is being dug and discharged. The discharge pipe is supported by a derrick which stands on the scow. Water is pumped into the hopper by a pair of ten inch pumps from the canal through a seven inch pipe which passes through the bottom of the boat and extends to the hopper, at top of bucket tower. A second pair of engines of thirty horse power raise and lower the ladder that supports the buckets; they are attached to a drum for that purpose. There is a hinged joint in the ladder outside of the derrick, for the purpose of operating one section of ladder independent of the other. A half inch cable connects the drum to the outward end of the lower section by two bails. The endless chain to which the buckets are attached is made of horseshoe iron 1⅛ inches by 9 inches. Another pair of spud and gypsy engines of thirty horse power is used for raising the spuds and feeding the buckets. The dredger rests upon the spud, upon which it can be revolved without stopping the dredging buckets, thus enabling the operators to dig from side to side at will. A chute connects with the hopper, and is boarded on the sides to prevent the mud or water from falling upon the deck. The fourth pair of engines, also of thirty horse power, is connected to a windlass for snag pulling. The engines are all supplied with steam from one set of three boilers, and will require only about two tons of coal each day. Six men, including a superintendent, run the entire machine. Capacity of the dredger, 1,000 cubic yards per hour.

The cutting of the canal is to be 100 feet wide at the bottom, 185 feet at the top, and 27½ feet deep.

A correspondent of one of our city papers, resident in New York, who has just returned from a visit to the works of the Panama Canal, writes:

The canal is an assured fact. The French seem thoroughly to understand the work before them, and have made admirable preparations to cover all contingencies. They take the greatest care of their employes, and their hospital service is unsurpassed in the world. A force of over twenty thousand men is a good many to handle, and, of course, entails a lot of red tape, but that seems necessary, especially with Frenchmen. But they have a grand chief in M. De Lesseps, and have now a splendid working staff in M. Diggler and his officers.

I was very anxious to see the Scotch dredger at work in the harbor of Colon, but it was not in operation during the eighteen days I was there. [For engravings and description of this dredger see SUPPLEMENT 431, April 5, 1884.] I was disappointed, as I wished to compare it with our mammoth American dredgers. It cost, I understand, £50,000, and is considered very good for deep-sea dredging, but for actual work I



THE AMERICAN DREDGERS NOW AT WORK ON THE PANAMA CANAL.

saw nothing there to compare to our American dredgers. I went on board and saw the latter work on many different occasions, and was highly satisfied. The principle is unique and very ingenious. The tower is iron, 75 feet high; the buckets and chains are of steel, and each bucket will and does take up 1⅛ tons of earth each lift. The spud, on which the dredge rests and revolves, enables it to take a sweep of 15 meters wide, and each move of the spud moves her forward 18 feet, so that, like a mowing machine, she cuts a swathe (to use a farmer's expression) 45 feet wide, 18 feet long, and 9 feet deep on each movement forward. They work perfectly, and it is indeed a grand sight to sit, as I have done, for an hour or two at a time, and watch them working. Rotten coral, roots, stumps of small trees, etc., all come up with the dirt, and make no difference. Of course, where rock is struck, or hard coral, or an old petrified monarch of the forest, blasting has to be done by the canal company ahead of us. Otherwise, after the ground is cleared of vegetation, trees, etc., we simply start in and eat—literally eat—our way through with absolutely no other preparation whatever, no men on shore working ahead or any other way. What we take out goes through the dredger's own discharge pipe on to the bank, and forms practically the bank of the canal proper. We have now cut from the sea (the harbor of Colon) three and a half miles of the canal by one machine, and some ten miles up we have two other machines entering from the Chagres River, cutting their way back to meet the first machine. A fourth machine leaves here to-morrow, and will join the others by the middle of January, while eleven more are building, and will follow, one each six weeks or so, until all are fairly at work. Our contract is for 30 million cubic meters, and will probably lead to half as much again, as it is conceded by the canal company and every one in the isthmus that nothing like our machines has been seen or used anywhere. One instance of their capacity I saw myself. A Suez dredger was put to work at a certain spot. After fifty days she was withdrawn, and one of ours took its place, and did in five days as much as the other had done. Our machines cost about $125,000 (say £25,000), and require about 20 men to work them.

SOME RECENT EXPERIMENTS WITH OIL IN STOPPING BREAKERS.*

THE U. S. Hydrographic Office, in pursuance of its policy to lessen the dangers of navigation, has recently commenced the collection of, information to determine the best manner of using oil to calm the surface of troubled waters.

This matter has long been a subject of controversy. In 1844 a Dutch commission, after pouring a few gallons of oil on the storm-beaten bosom of the North Sea, and finding the waves not sensibly affected, declared that the oft-repeated account of the saving of ships by this means was a fantastic creation of the imagination. Notwithstanding this, Scotch coasters have saved themselves again and again by strewing the sea with the fatty parts of fish, cut into small pieces, which were carried with them for the purpose; and so much reliable information on this subject has now been collected from the common experience of seafaring men, that the evidence in its favor can no longer be controverted.

It must be understood, however, that the use of oil does not make the surface perfectly smooth, but merely lessens the dangerous effect of what the seaman calls "combers," or the great broken, rolling masses of water which have first disabled and then swamped so many ships since man first began to go down to the sea.

A case lately reported of the use of oil is that of the steamship Thomas Melville, while running before a gale in February, 1884, when she was constantly boarded by heavy seas. As her situation became more and more critical, it was determined to try what effect oil would have upon the water. Two canvas bags holding about a gallon were made, therefore, punctured in many places with a sail-needle, and filled with oil. These bags were hung over the bows, and allowed to drag in the water. The seas no longer came on board, and the safety of the vessel was secured. The bags were refilled every four hours.

The application of oil to the quieting of water at the entrances of harbors is one that has received very considerable attention; and credit is due to Messrs. Shields and Gordon of England for their energy and enterprise, as well as for the thought, time and money expended in endeavoring to establish its use, and in bringing the subject into prominent notice.

At Folkestone, Eng., Mr. Shields's apparatus consisted of three large casks placed on shore at the end of the old mole. These were connected by pipes with small hand-pumps, each of which was worked by one man. Two lead pipes about an inch and a quarter in diameter extended from the casks along the bottom, through the entrance to the harbor, about 2,950 feet toward Shakespeare's Cliff. At intervals of every hundred feet, vertical pipes were soldered to the main pipes; and in the former were placed conical valves properly protected from mud and slime by caps.

Unfortunately, on the day set apart for a public exhibition the weather was not entirely favorable; that is to say, the wind was not from the right direction. The sea, however, was sufficiently disturbed to show the working of the apparatus. When the oil was pumped through the tubes, it soon showed its effect upon the surface; and this became more apparent as the amount of oil was increased.

A broad glassy strip was soon distinguished which was more than a half-mile long. A fully manned lifeboat, which was sent into the oil-covered strips of water, was tossed about in a lively manner, but took in no spray. Meanwhile the sea outside of the strip was everywhere breaking into white caps. After stopping the pumps, it was found that the amount of oil used was a little over a hundred and nineteen gallons.

Three hours after the close of the trial, the Boulogne steamer passed broad strips of comparatively smooth water, on which the oil still lay.

After this experiment, two of Mr. Gordon's inventions were tried. One of these consists of a shell fired from a mortar, and so arranged that it bursts on striking the water, and frees its contents of oil. The shell is specially constructed, and has an ingenious device for insuring its explosion, which is effected by a fuse and gunpowder. This recommends itself as a practical means to render less dangerous the communication between ships by boats during heavy weather. In case of shipwreck, also, the approach of lifeboats could be greatly facilitated.

The second invention is an arrangement to make a lane of oil from the shore to a stranded ship. To effect this, an iron cylinder is fired from a mortar in the direction of the ship. The cylinder, which serves as an anchor, draws after it a leather hose fastened to it by a line. Oil is then pumped through the hose, and, being spread toward the shore by the wind, forms a quiet surface for the rescuing boat.

Various ingenious contrivances have been invented for applying the oil to the water; but the simplest and readiest, at the same time most effective, appliance is a canvas bag, either rather loosely sewed together, or pierced with small holes to allow the oil to escape. This has been the method adopted in the most successful cases reported from ships at sea, and has been found effectual in some of the lifeboats. It has the great advantage of being self-acting, insuring a regular stream of oil, and being easily renewed when exhausted.

In a vessel or boat running before a sea, one should be hung over each bow, which gives the oil time to spread before reaching far astern. In a ship, when hove to, one or more bags have sometimes been hung over the weather side, and sometimes been put overboard to windward attached to light lines. This is the best plan, because, not drifting so fast as the ship, the bag will be carried to windward, and fulfill the condition of applying the oil to the water at some distance from the ship, in the direction from which the waves are advancing.

An open boat unable to run before the sea will always endeavor to put out some form of sea-anchor, with a rope attached to it: the bag of oil should be attached to this, and, failing every thing else, a boat's mast or a sail loosed is very effective.

When the boat is anchored, the bag could be attached by a light line to the anchor as a buoy. This appliance, in addition to being efficient, has the great merits of handiness and simplicity. Two such bags, holding about a gallon of oil each, with the line attached, might be kept full, and packed in a small cylinder similar to a paint-pot or a preserved-meat tin, and would form neither an expensive nor cumbersome article of equipment in a boat.

In the absence of these or similar contrivances, the oil could be poured from a bottle or can; but this would require a man's attention when one could be ill spared possibly, and might not insure so constant or regular a supply, which is of importance. This would not be applicable to a boat at anchor.

* Communicated by Capt. J. R. Bartlett, chief hydrographer of the navy.—Science.

STEAM LAUNCHES AND CUTTERS.

THE development of the torpedo as a weapon of defence, and the important part it seemed likely to occupy in any future naval war, led Mr. J. S. White to consider a means for obtaining increased maneuvering powers in his boats, this being one of the important factors in the problem of using torpedoes with greatest effect. The result was that about three years ago a boat was produced on what is known as the "double-rudder system with after deadwood removed." The first vessel built on this principle was a 42 ft. pinnace, which was purchased by the Government after completion, and formed part of the boat equipment of the Inflexible when she was commissioned by Captain Fisher. We had the pleasure of being on board this little vessel during a trial, and shared in the surprise and admiration which her extraordinary powers of turning circles elicited from all those present. Figs. 3 and 4 show a vessel fitted with this arrangement. There is also a perspective view of the same boat. By the profile view it will be seen that the deadwood under the quarters is entirely removed, and the propeller shaft is carried out through a projecting stern tube which is supported at its extremity by a depending bracket. There are two balanced rudders, one before and the other abaft the propeller in the usual way. The latter is supported under the keel by a curved metal arm, while the former fits into part of the angular space left between the after part of the boat and the stern tube. Both rudders are turned simultaneously by one steering wheel, through worm and wheel and chain and sprocket gear. The vessel illustrated by Figs. 3 and 4 is one of a new class recently introduced into the service, and known as "torpedo boats, wood." These vessels are 56 ft. long and 10 ft. wide, and are built of mahogany. There are two diagonal skins $\frac{5}{16}$ in. thick, and a fore and aft planking ⅜ in. thick. The garboards are 1 in., ¾ in., and ½ in. All thicknesses are fastened with copper nails clinched on roves. The planking is carefully fitted and no calking is used, but between the two skins calico is placed which is well paid with marine glue. In this way the boats are always tight however dry they may be, an important consideration, especially in hot climates, with small craft that may be called on for services at any minute, perhaps after having been out of water for weeks or month. Bent timbers of American elm are used; these are 1 in. by ⅞ in., spaced 10 in. We may here remark with respect to these boats that they have the same scantling as the 45 ft. pinnaces, and this is found quite strong enough. The position of the screw as carried by the bracket, and the removal of the deadwood aft makes them very steady under steam; so much so that there is less vibration at 15 knots than in the other pinnaces at 10; hence the lighter scantling is sufficient.

The decks are double planked, with calico and marine glue between. The deck beams are of wood. The boiler is cased in galvanized iron with felt underneath. The cock-pit is covered with a canvas hood, and the boat is steered just forward of it, as shown. The helmsman is protected by a shield, and in this position he is able to give orders directly to the engine room. The air spaces at the side run from end to end, and there are also air spaces in the bow and stern, as shown by dotted lines in the deck plan. The planking of these air compartments is in two thicknesses, ¼ in. each, with calico and marine glue between.

The space forward of the boiler is used for the crew and for fighting the bow gun. Bilge ejectors are fitted which are capable of throwing 30 tons of water an hour. No special sleeping arrangements are provided by the contractors, but it is evident that the boats would afford fairly comfortable accommodation for the complement of officers and men required for them if it were necessary to make a lengthened cruise on active service.

The bunkers hold about 12 cwt. of coal, but much more can be carried in bags on either side of the boiler. The bunker coal is estimated to take the boats about 120 miles at a fair speed, say about 10 knots. With an extra ton, which could be easily stowed on board in case it might be necessary to make an expedition away from the ship, a distance of about 330 miles could be covered at a fair speed without re-coaling.

The following table (D) is compiled from an official report of the trial of one of the most recent of these vessels:

Measured Mile Trial of H.M. Torpedo Boat, Wood, No. 5. Full Power.

Date	December 19, 1883.
Where tried	Measured mile, Stokes Bay.
Draught of water — Forward	1 ft. 11 in.
Draught of water — Aft	4 ft. 8 in.
Average boiler pressure	126 lb. to sq. in.
Mean pressure air in stokehold	2.75 in. of water.
Average vacuum in condenser	28 in.
Weather barometer	30.33
Mean revolutions per minute	385.03
Mean pressures in cylinders — High	51.65 lb.
Mean pressures in cylinders — Low	22.783 "
Mean pressure in receiver	39.33 "
Mean indicated horse-power, high-pressure cylinder	67.63 (total 142.00)
Mean indicated horse-power, low-pressure cylinder	74.37 (total 142.00)
Speed of vessel	15.562 knots
Wind — Force	One.
Wind — Direction	Ahead and astern.
State of sea	Smooth.
Quantity of coal on board	6 cwt.
Description	Nixon's navigation.
Engines:	
Makers' name	Belliss and Co. (boat by John Samuel White).
Description	Inverted compound condensing.
Number of cylinders	Two.
Diameter of cylinders, high-pressure	9½ in.
" " low-pressure	15 "
Length of stroke	9½ "
Boiler:	
Number of furnaces	One.
Length of firegrate	2 ft. 7½ in.
Breadth "	2 ft. 8 in.
Propellers:	
Twin or single screw	Single.
Number of blades	Four.
Diameter	3 ft. 5 in.
Mean pitch	4 ft. 6¾ in.
Greatest length	7½ in.
Immersion of upper edge	9¼ in.
Area of rudders — Main	8 sq. ft.
Area of rudders — Auxiliary	4 sq. ft.

Circles.

—	Full Power.	
	To Starboard.	To Port.
Angle of rudder	45 deg.	45 deg.
Full circle made in	38 secs.	37 secs.
Revolutions per circle	182	177
Diameter of circle in boat's lengths	2 to 2¼	

The engraving below is taken from a photograph of the vessel above referred to. It will be seen that it is a handsome, wholesome-looking boat, and good for ordinary ship's purposes, as well as for torpedo warfare; a point of considerable importance especially in smaller vessels of war where the number of launches carried is limited.

Many efforts have before now been made to increase the steering powers of the boats, but the end has generally been gained at the expense of speed. In the present case it will be seen that a vessel has been produced in which speed, as a remarkable feature, is only second to quickness on the helm. Mr. White has applied his double-rudder system to larger vessels than pinnaces and torpedo boats. A yacht built for Lieut.-General Baring has given very good results. He has also recently completed for the War Office a steel vessel measuring 140 tons and having 350 indicated horse power, the results of the trials of which we hope shortly to publish.

In the Royal Navy, steamboats are supplied to all classes of ships in accordance with their supposed requirements, but there is no very definite complement. A first-class ironclad has generally two pinnaces of 37 ft. or 48 ft. type, and one cutter. The smaller ironclads have one pinnace and one cutter. There is a special 21 ft. cutter, the smallest steamboat made, which is supplied to gunboats. Flagships and ships having special duties have generally an additional steamboat. In addition to the above there are also the torpedo boats proper of the second class, two of which form the complement of the larger ironclads.

The pinnaces are fitted with side lever torpedo lowering arrangement similar to that orginally designed for the second-class torpedo boats for launching Whitehead torpedoes, or else they are arranged for spar torpedoes. The larger cutters are also fitted for using spar torpedoes. Both classes have metal protection hoods fitted over the forecastle, behind which the crew can work, and so gain some protection from the lighter missiles.

The 25 ft. cutters are clinch built of mahogany and teak. All above this size are diagonally planked in two thicknesses of the same wood, with waterproof material between, as before described. They are capable of floating on their diagonal skin, should portions of the longitudinal outside planking be accidentally knocked away.

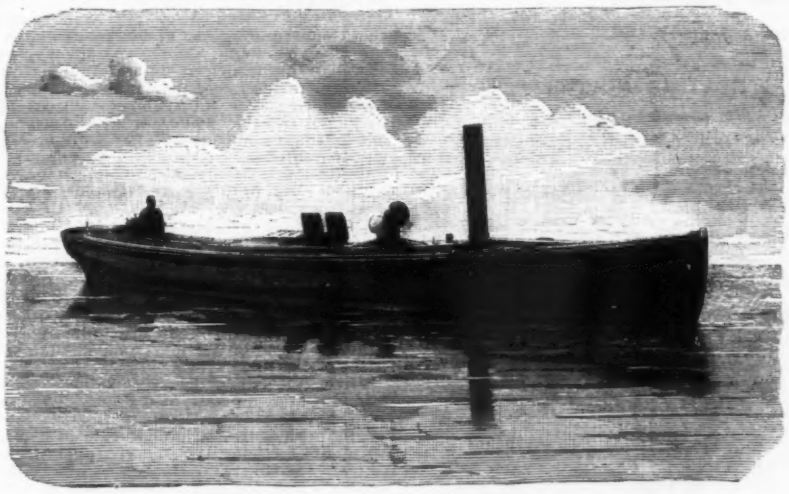
One diagonal skin of the 27 ft. and 30 ft. boats is ¼ in. thick, the other, as well as the fore and aft planking, is $\frac{3}{16}$ in. The garboards are ½ in. diminishing to the thickness of the bottom. All these boats are fastened with copper nails clinched on roves. The timbers are of American elm ⅞ in. by ⅞ in., spaced 8 in. apart. In

the arrangement of air-tight spaces and other general details all the diagonal boats are built in a similar manner to the 56 ft. boats already described. The 37 ft., 42 ft., 45 ft., and 48 ft. boats are of the same scantling as the torpedo boats, wood (56 ft.). Hatches are not provided for covering the open spaces, but canvas covers are generally fitted by the naval authorities. It is only in some of the 48 ft. boats and in the 56 ft. classes that the engines are inclosed. When forced draught is used and the engines are not under cover, the boiler is stoked from forward, the stokehold being covered in.

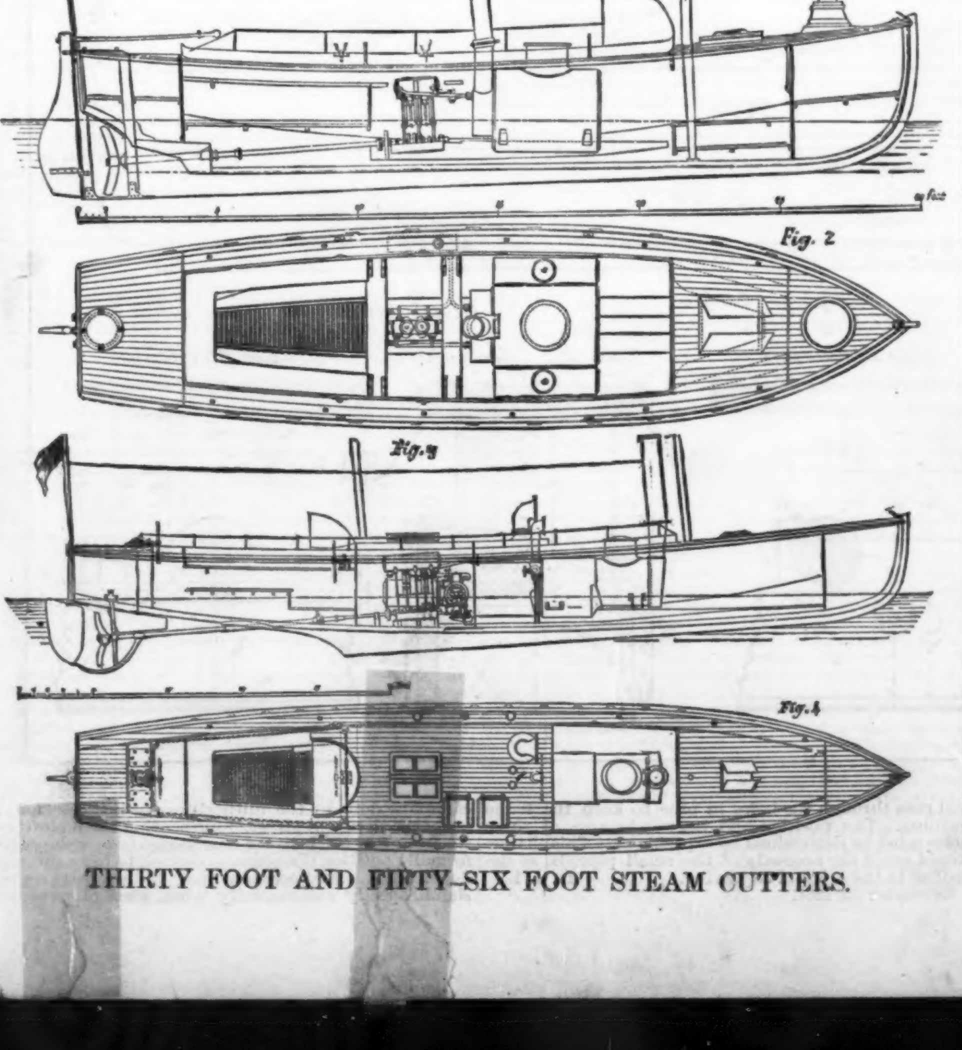
The amount of hard work and rough usage boats built on the diagonal system will go through is well known. Their durability is due to the yielding nature of the materials and the elasticity imparted to the whole fabric by the diagonal construction. No class of boats are subjected to a more trying ordeal than are the steam pinnaces and cutters in the course of service in the Royal Navy. They are worked constantly, and must be able at any time to submit to any unlucky knock that would send an ordinarily constructed boat to the bottom. That they last so well, and meet with so few serious accidents, is the best proof of the excellence of their build, and the suitability of the material employed in their construction.

Mr. J. S. White and Messrs. Belliss are firm believers in the benefits of the compound surface condensing system for all classes of boats, and they are now fitting compound engines with outboard condensers to all classes of boats down to 21 ft. The great difficulty in the way of applying condensing engines to small boats arises from the necessarily short chimney that can be used, and the consequent feeble natural draught that is obtained. For this reason enough fuel cannot be burned on the ordinary grate area to generate sufficient steam, unless the exhaust is utilized for forcing the draught, or a steam jet is placed in the chimney. The latter alternative affords but a poor makeshift, and the principal benefit sought to be gained by surface condensation, *i.e.*, the saving of fresh water for the boiler, is by it, to a great extent, lost. It has been found, however, that by means of a specially constructed boiler, having a far greater proportionate area of grate than usual, sufficient steam can be generated for the purpose required, the large size of the fire compensating for its want of intensity. There is a second advantage to be gained by these big fires and slow combustion. The boiler can be run for a far longer time without coaling. We have seen a 25 ft. boat with compound surface-condensing engines run for three hours, during which time the firedoor was only opened once. This naturally makes the work of firing very light. To such an extent is this the case that the little vessel referred to was constantly run single-handed, often for a whole day at a stretch, and this too over the most crowded parts of the Thames, that is to say between Chiswick and Gravesend. We mention this fact because an idea is prevalent that the compound condensing system is too complicated for small boats. This is true enough should the machinery be badly constructed or badly kept up; but good machinery, designed by a capable engineer and well looked after, will run in ordinary work without causing undue anxiety and with a minimum amount of attention.

Mr. White places the condensing pipe alongside the keel so as to avoid all risk when the boat grounds. By a compact arrangement the air pump and machinery are made to take up practically no more room than with the ordinary simple engines. It is unnecessary for us to refer at length to advantages of compound engines or surface condensation for marine purposes. The desirability of recovering the water evaporated for again feeding the boiler is in itself a sufficient recommendation for the latter feature. There is one point, however, which is of the highest importance with boats that are to be used for naval purposes as well as for pleasure craft, and that is the necessity of getting a high rate of speed without the accompanying noise of blast in the funnel. The great thing desirable in a torpedo attack by boats, is to take the enemy by surprise and deliver the fatal blow swiftly and silently. The impossibility of achieving this under ordinary, or rather probable conditions, with the old-fashioned "high-pressure" launches will be obvious to all who have had the handling of such craft.—*Engineering.*



FIFTY-SIX FOOT CUTTER, BY J. S. WHITE.



THIRTY FOOT AND FIFTY-SIX FOOT STEAM CUTTERS.

THE GREAT ATLANTIC STEAMSHIPS.—THEIR DIMENSIONS AND POWER.

THE following table shows the size and power of the largest steamers now running on the Atlantic:

VESSELS.	Length between Perpendiculars. Feet.	Extreme width. Feet.	Depth of hold. Feet.	Indicated H. P.	Gross tonnage.
Alaska	500	50	38	11,000	6,932
America	442	51·2	36	7,500	5,528
Arizona	450	45 4	35·7	7,400	5,164
Aurania	470	57·2	37·2	9,500	7,269
Austral	456	48·2	33·9	7,000	5,589
Britannic				4,900	5,004
City of Rome	560	52·3	37	10,000	8,144
City of Berlin	489	44·2	34·9	6,000	5,491
City of Chicago	431	45	33·6	6,600	5,202
Furnessia	445	44·8	34·5	5,500	5,495
Germanic and Britannic	445	45·2	33·7	7,000	5,008
Servia	515	52·1	37	8,500	7,392
Oregon	501	54·2	38	11,500	7,375
Umbria and Etruria	505	57	40	12,500	8,000

The greater width and depth of the two newest and most powerful steamers, the Umbria and Etruria, as compared with the City of Rome and some of the others, are noteworthy.

The following were some of the performances of three of these ships in 1884:

	Fastest passage. Dys.	hrs.	min.	I. H. P.	Fuel per day. Tons.	Tonnage.	Speed. Knots.
S. S. Oregon	8	12	27	12,000	265	7,250	18
" America	6	14	18	7,368	175	5,530	17·82
" Britannic	7	12	17	4,900	100	5,004	15·8

It will be seen that the gain on time of the America over the Britannic is 22 hours, and the extra power required to gain this advantage is 50 per cent. The America's tonnage is 10 per cent. greater than the Britannic's.

BINARY VAPOR ENGINES.

THE failures which have attended the numerous attempts to substitute the vapors of other liquids than water for motive power purposes have not deterred later inventors from repeating the experiments.

The latest move in this field is a mixture of methyl alcohol, commonly known as wood alcohol, directly with the water in the boilers. The patentee has, we understand, received a liberal sum in the United States for a patent claiming the use in boilers of such a solution containing five to fifteen per cent. of wood alcohol.

A commission of United States naval engineers recently made a very careful test of this mixture containing 15 per cent. of wood alcohol, by running a launch engine 24 hours with steam, and also 24 hours with the mixture.

The results showed an economy of combustible alone of 8 3/10 per cent. in favor of the binary vapor, but at a much larger expense to supply the loss of the wood alcohol by leakage. To save 22 1/10 cents' worth of coal at 3·17 dols. per ton, required a loss of 12·32½ dols. worth of wood alcohol at 1·25 dols. per gallon. Thus to enable the binary vapor to compete with water under these conditions, the cost of wood alcohol must be 2¼ cents per gallon, or one sixty-seventh of its market price.

In each instance the experiments were conducted in the same manner in every particular, and the same data observed and noted. A slight modification in the surface condenser during the first set of trials resulted in a variation of conditions, and the following data were taken from a second test.

The engine, boiler, and surface condenser were new, and run for a few days previous to the trials to get into good running order.

	Steam.	Compound Vapor.
Duration of experiments ... hours	12	12
Revolutions per minute	200·79	208·94
Boiler pressure ... lb.	78·73	76·56
Vacuum ... inches high	26·31	23·06
Feedwater ... deg. Fahr.	111·81	115·31
Injection water ... "	82·56	80·75
Discharge ... "	95·22	94·69
Coal per hour ... lb.	47·08	49·67
Combustible per hour ... "	40·42	44·33
Coal per square foot of grate ... "	9·91	10·46
Combustible " " "	8·51	9·33
Indicated horse power	8·18	9·79
Coal per hourly horse power ... lb.	5·76	5·07
Combustible " " "	4·94	4·53
Saving in combustible, per cent		8·3

The report concludes with the statement that, "although it is not clear in the minds of the Board how a vapor requiring less heat in its production can give up more of its heat in the production of power than another vapor under like conditions containing a greater quantity of work, yet, accepting the result of trials

as being absolutely correct, it would be well to see what this saving costs." And then follows a discussion of the results as given above.

Latterly this same compound was tried on a larger scale in supplying an engine indicating 150 horse-power, which was used to assist the water wheels in running a cotton mill. The solution contained about 12 per cent. of wood alcohol, but the alcohol, on account of its low boiling point (161 deg. Fahr.), evaporated more rapidly than the water, and after six hours' use it was found that the solution in the boilers had reduced to seven per cent., while the condensed vapor in the hot well contained 38 per cent. of wood alcohol. The odor of the vapor was intolerable, being as much more offensive than that of the liquid as the fumes arising from rubber placed on a hot iron, are compared with the smell of the rubber in an ordinary state. The vapor escaped through leaky valves into the boiler used for heating, and the smell from the vapor blown into the weaving rooms from the vapor pots used to preserve the humidity of the air was so great that some of the helps were taken with severe nausea.

In the engine room the leakage around the stuffing-boxes filled the room with a noxious vapor, severely irritating to the eyes. The vapor is far more permeating than steam, and it seemed to be practically impossible to prevent numerous leakages.

A two days' trial resulted in disappointment to those who expected to learn of an economy in fuel, and on the other hand the loss of the wood alcohol by leakage was excessive. The proportion of alcohol in the compound vapor was shown to be dangerously inflammable, and the leaking vapor injurious to persons.

After four days' use, this "bunkum borum" was ejected into the river, doubtless resulting in "the better for mankind, and the worse for the fishes," as Dr. Oliver Wendell Holmes described the effect of sinking *materiamedica* in the sea.—*Engineering.*

A NEW ENGLAND COASTING SLED.

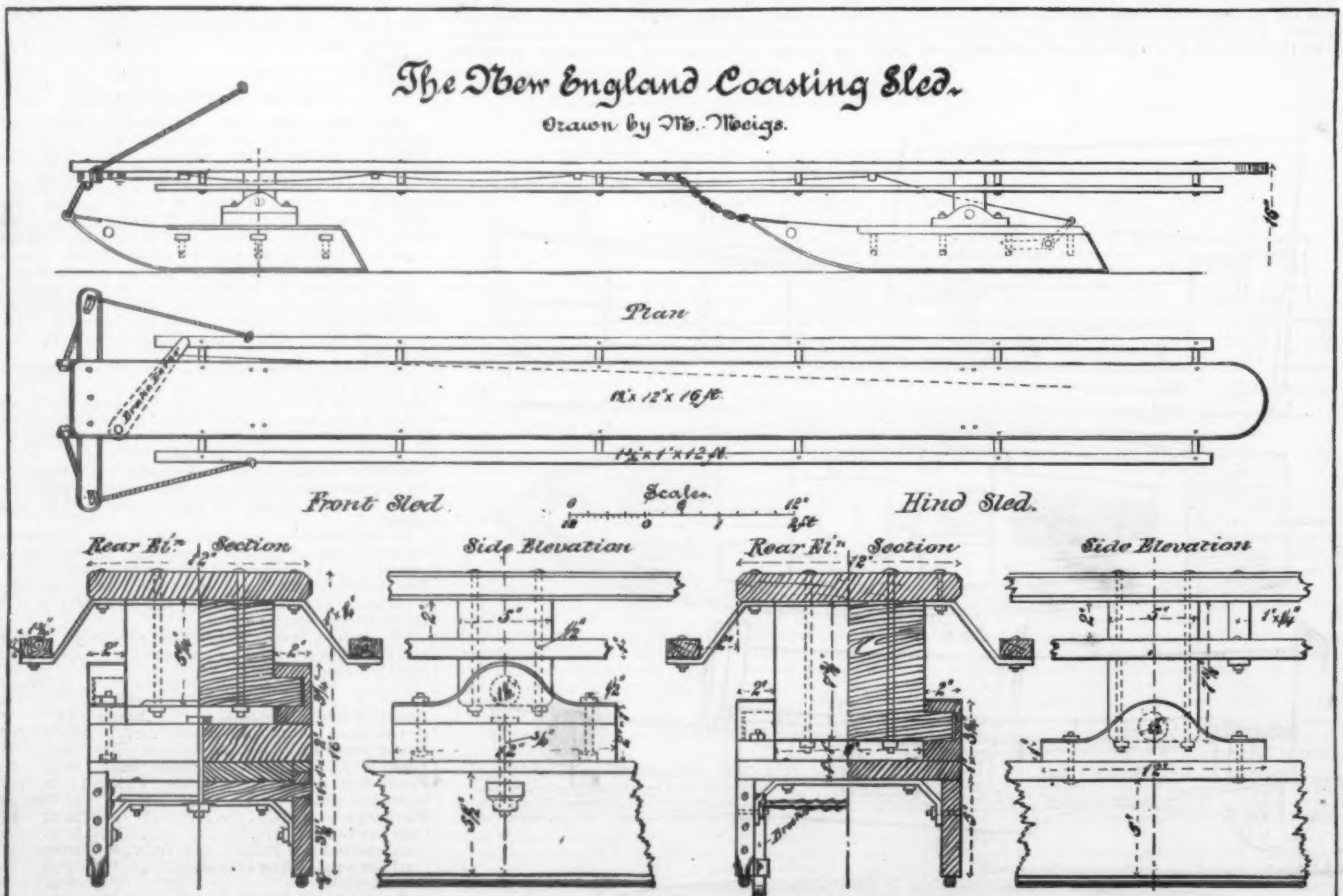
To the Editor of the Scientific American:

The drawing herewith was made from sketches furnished by Mr. F. S. Codman, of Brookline, Mass., who built this sled, and represents a good form of the New England double runner or coasting sled used every winter by scores of young people in Massachusetts and other New England States. The sled consists of a seat 16 feet long, 12 inches wide, with two rails or foot rests at the side, and is intended to accommodate from nine to twelve people. The seat must be of clear hard pine, ash, or some equally elastic and strong wood. The rest of the sleigh should be of oak and very strongly put together, as the load is sometimes 1,800 lb. and the speed anywhere up to thirty or forty miles an hour. There are two sets of runners shod with octagon or round tool steel ⅝" diameter, the latter being welded at each end to flat iron 1"×¼", and the latter strongly fastened with screws or drift pins. Tool steel should be used if satisfactory speed is desired, for soft steel gets scored and rough very easily. The sled runner should be grooved ⅛ inch to keep the steel shoe in place. The front sled turns about the kingbolt, shown in drawing, and is steered by the two hand ropes shown passing over pulleys in the ends of cross bar. I have added to this machine a brake operated by a pivoted lever with the foot. It consists of two pieces of steel 1" × ⅜" connected by an iron bar ⅜ inch diameter on which they are keyed. On the cross bar there is a tumbling crank connected with the brake lever at the front of the sleigh by means of a stout wire. The cross shaft has its ends turning in holes bored in the runners of rear sled, and there are two stops of iron bolted tightly to the inside of sled runner near the bottom. The plan shows all pretty clearly. When the foot is placed on the brake lever and the latter is forced forward, the steel teeth are depressed and catch in the ground, soon bringing the sled to a standstill. A spring is coiled on the cross bar, and keeps the teeth elevated except when the wire is drawn and the tumbling crank pulled forward.

The under side of the 2-inch block which forms the "fifth wheel" of the forward sled should be soaped or greased to make it turn readily.

M. MEIGS, U.S.C.E.

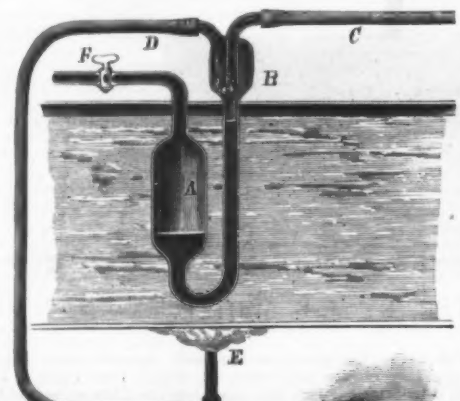
Keokuk, Iowa, January, 1885.



HEAT REGULATOR.

To the Editor of the Scientific American:

In the SCIENTIFIC AMERICAN SUPPLEMENT, No. 451, I see a description of a heat regulator. I think



that there are one or two changes that might be made with advantage. The limb, B, might be enlarged above the level of the water in the heater, and the supply pipe projected down into it. This part of the supply pipe should have several small holes pierced in it. The inclosed sketch will give an idea of what I mean. Then as the mercury rises to the point B, the end of the supply pipe will be closed, but enough gas will pass through the holes in pipe to keep the flame burning. The position and aggregate area of these holes must be determined by experiment. This change would avoid the necessity of the small pipe, H, as described in the original engraving.

D. G. E.

December 12, 1884.

STREET PAVEMENTS.

By WM. B. KNIGHT.

KANSAS CITY is divided topographically into two distinct parts, the main portion of the site being a high, broken ground, elevated 100 to 200 feet above the Missouri River, and the smaller portion being level "bottom land" lying beyond the base of the bluffs and only about 25 feet above low water mark.

The soil of the upper town is a rather yellowish clay containing generally a small proportion of silica, and most of it is suitable in its natural state for making brick of fair quality. It softens easily and becomes slippery, and is of greasy appearance, when moistened. The street gradients in the main part of the city may be stated as ranging from 2 to 5 per cent., on the north and south streets, and generally about half as great on the streets running east and west—although on some of the latter are found some of the steepest grades in the city—varying from 6 to 13 per cent.

The city ordinances passed last year require a three inch width of tire for loads up to 3,000 pounds and a four inch tire for loads not over 6,000 pounds. As a matter of fact, however, loads of 7,000 pounds are commonly hauled on wagons with two and three quarter inch tires, and the ordinary two-horse wagons, carrying loads of 3,000 to 4,000 pounds, have tires usually only two inches wide.

In the lower town the natural soil is a fine, light sand which becomes saturated with water during flood stages of the river, and on which there has been deposited, in the artificial process of filling up, a top layer of clay and debris ranging from one to three feet thick. The widths of streets vary from fifty to ninety-nine feet, a majority of the principal streets being sixty feet wide. A general law of the city makes the roadway three-fifths of the total width.

Street railroad tracks are usually of four feet gauge, laid four and one half feet apart. The lines are, as a rule, double track on business streets.

The work of paving the streets of Kansas City may be said to have begun, properly speaking, in the spring of 1882. At that date there were ninety-three miles of streets within the corporate limits of the city; of which fifteen miles had been macadamized, the remainder being simply dirt roads.

In the spring of 1882 all of the principal streets were in a very bad condition. The first contract for paving any street otherwise than macadamizing was let in February, 1880. The specifications called for Medina (N. Y.) sandstone, cut after the Belgian form, and six to seven inches deep, laid on a six-inch bed of coarse sand, and with the joints between the blocks filled with asphalt paving cement. The cost was $3.50 per square yard. The work was not, however, completed until January, 1883. Meanwhile the second contract had been let, in February, 1882, for paving with round white cedar blocks, six inches long, set on one inch boards, bedded on three inches of sand. The spaces between which were rammed full of sand, and a coating of asphalt paving cement spread over the surface. The cost was $1.75 per square yard.

Under the law of this city, the paving of any street cannot be done by the authorities until the owners of property along the street, representing the majority of the front feet (exclusive of non-resident ownership) shall formally petition the common council to have the work done. It is also necessary that the property owners should specify substantially what kind of pavement

they want laid down. The entire cost of the work is assessed against the property fronting on the street. For cedar block pavement the roadway is excavated to proper depth and made to conform to the shape to be given to the finished surface of the pavement. Care is taken to secure, as far as possible, uniform density of the subgrade, by the use of a two-ton roller, (the only one available,) and by filling in soft spots with broken stone and ramming them down into the soil.

On this sub-grade is placed a layer of hydraulic cement concrete nine inches thick on some streets, and six inches thick on others, depending principally on the character of the formation, location, and character of the street, whether it is a business thoroughfare or street in a residence part of the city. In an exceptional instance the depth of the foundation has been reduced to four and one half inches by the property owners, although, generally, the popular disposition has been in favor of the nine inch base on streets of all kinds.

The concrete is composed of five parts, by measure, of clean limestone, broken to go through a two and one-half inch ring, and two parts of clean, coarse, river sand with one part of approved hydraulic cement. The sand and cement are thoroughly mixed dry, and then wet, and the mortar spread over the stones, which are spread out in a layer in the box. The mass is then thoroughly mixed together and loaded out into a wheel-barrow, and deposited in place, and rammed until mortar flushes to the surface. The cement is required to stand thirty-five pounds tensile strain per square inch after twenty-four hours. The brands used have been "Fort Scott," Kan., "Milwaukee," and various kinds of Louisville. On the surface of the concrete, which is made to conform to surface of street, a layer of sand is spread about one half inch deep, or sufficient to fill up all minor irregularities of the surface of the concrete, and make an even bearing for the blocks. The blocks are of white cedar, varying from four to eight inches in diameter, and are required to be cut from good, sound live timber. They are usually seven inches long when set on nine inches of concrete, and six inches on the lighter base. They are sawn with parallel ends by gang saws, and are laid up as close together as practicable in the street. The interstices between the blocks are twice swept full of gravel, which ranges in size from one quarter to three quarters of an inch, and rammed down with round pointed iron rods. After the first ramming, the surface of the block is made smooth and uniform wherever it may be uneven by going over it with a light paving rammer.

Asphalt having cement, composed of coal tar, distilled at 300 to 400 degrees, and mixed with 15 per cent. of mineral asphalt, is poured hot over the pavement, filling up all the minor interstices between the blocks. A thin coating of sand is then thrown over the surface before the asphalt dries.

The first price at which this kind of pavement was let was $3.25 and $2.96 per square yard, for parts of Fifth and Sixth streets, in the spring of 1882. This was for seven inch blocks on nine inch concrete. Since then the cost of this work has been constantly decreasing with each successive letting. The last work contracted for was let at $2.44, and the average price paid during the season was $2.56.

For six inch blocks on six inch concrete, the price has varied from $2.32 on the first to $2.18 on the last contract let.

The ordinary wages for common labor has been $1.75 per day. The materials used cost about as follows: Seven inch cedar blocks, 80 cents to 85 cents per square yard measured in the street, and six inch blocks about 17 cents less. For gravel, 10 cents to 12 cents per square yard of pavement with seven inch blocks. For asphalt paving cement, 15 cents to 18 cents per yard. The broken stone for concrete costs $1 per cubic yard, and sand about the same. Cement varies from $1 to $1.25 per barrel of about 260 pounds. The concrete in place is worth about $3.50 to $3.75 per square yard. One block of seven inch cedar block pavement has been laid during this year on one inch boards with four inches of sand underneath at a cost of $1.95 per square yard.

Observation on the wear of cedar block pavement with concrete base shows a good, smooth surface and very uniform wear.

Blocks taken up at the intersection of Fifth and Main streets, in the center of the business part of the city, eighteen months after laying, showed a very regular wear of one-quarter to three-eighths of an inch. Blocks taken up for water and gas connections on the most crowded parts of Fifth and Sixth streets, where nearly all the heavy loads are confined to the ten and one-half foot strip of paving between the railroad track and the curb, show a wear of about three-eighths of an inch in nearly two years.

There has been no repairing done on these streets, and there is no indication that any will be for some time. The blocks are so thoroughly fastened together that sections of four to six square feet have been taken up without breaking. No swelling of the blocks and raising of the concrete has been observed. In very cold dry weather fine cracks appear running nearly directly across the surface of the pavement. They usually occur on steep grades, and open from one to one and one-half inches if the extreme low temperature continues, but close up again with warmer weather.

The first stone pavement laid after the Medina stone, on a part of Fifth Street, was on a part of Bluff Street. It was expected that a sufficient thickness of the old MacAdam metal would be found to form a good foundation on most of this street, considering the tons of broken stone that had been hauled there during the previous years. In the absence of this the specifications called for a six inch concrete foundation, which, in fact, was found necessary over the entire street. On this was placed a layer of two to four inches of sand. Rectangular blocks of the Argentine or other good quality of native stone was used for the wearing surface on my recommendation. This pavement cost $2.95 per square yard, or about $2.35 exclusive of the concrete base.

A line of three inch agricultural tile drain pipe was laid along each side of the street near the gutters—that on the east side being for the purpose of draining the wet soil at the base of the hill, along which it runs, and that on the west side for subdrainage and protection of retaining wall.

Observations on the wear of this paving show numerous minor depressions of the surface, principally along the east side, and are due partly to unequal wear of the blocks and partly to settling of some of the numerous excavations made and imperfectly refilled, just in advance of the pavement.

A very superior quality of sandstone block pavement has been laid during the past season on Union Avenue. The stone is a firm, small grained, metamorphic sandstone of pinkish color, quarried in the foothills of the Rocky Mountains, in Boulder County, Col. It lies in well defined and fully separated ledges varying in thickness from one inch to several feet. The ledges selected for paving stones are from three to four and a half inches thick, and the blocks are cut out from eight to twelve inches long and six inches wide. The Union Avenue pavement has a concrete base of nine inches, with two inches of sand on top, and has the joints swept full of sand. The side joints are smooth, corresponding to the natural top and bottom beds of the stone in place, and the ends recut to lay to one-half inch joint.

This pavement cost $5.38 per square yard, or about $4.25 exclusive of concrete. The stone cost on cars here about $2.50 per square yard, measured as laid. Portions of this pavement that have been under heavy and continuous traffic since first put down indicate excellent wearing qualities. A part of Mulberry Street, West Kansas, has also been paved with this stone, on a nine inch bed of sand, with a well prepared sub-grade. East Ninth Street, from Main to Grand Avenue, is now being paved with the same material, on six inches of concrete. The grades on these two blocks are 8 and 13 per cent.

Walnut Street from Twelfth to Twentieth, about 4,600 feet, was macadamized last year. The stone was carefully selected for hardness, and was broken to size from three and one-half inches to two inches. They were spread on in three layers, one of five and two of four inches each, making a thickness when rolled of thirteen inches at center of roadway, and eight inches at gutters. The top layer is of very hard flinty rock, and was mixed with a binding material of sand and clay; the only roller available was an old one weighing about 4,000 pounds, and was altogether too light to compact the metal. There was considerable travel over this street while the work was in progress, forming well-defined ruts in the loose stones along the center. The street has been carrying a large and heavy traffic for a year now, and is in very good condition, although it has had no repairs at all. This work costs sixty-three cents per square yard.

A portion of Hickory Street in West Kansas, about half a mile long, was paved under the Telford-MacAdam specifications, at a cost of seventy-eight cents per square yard. It has had no repairs since completed, and has been carrying a very large traffic with reasonably satisfactory results.

All the materials used and the execution of the work is under constant supervision, one and frequently two inspectors being assigned to each street piece of work, the whole work being under the immediate charge of the Superintendent of Construction, and care is taken to insure good workmanship and a substantial compliance with the specifications throughout.

The drainage system of the street surface is from the center each way to the gutters, and along the gutters to sewer inlets at nearest street corners.

The standard form for paved streets makes the pavement at the center of the street level with the curbs, and thence sloping down on curved lines to eight inches below this level at the curb line, excepting in the case of MacAdam streets, which are designed to have twelve inches fall to the gutter. Considerable variation, however, is found to be necessary on account of the existence of single or double lines of street railway tracks along the center of the roadway, and frequently on account of streets where the old established grade varies from "level across" to three feet higher on one side of the roadway than on the other. Some modifications are advisable, too, in cases of steep longitudinal grades, but the general purpose has been not to make the cross-slope greater than eight inches in eighteen feet, and to make the gutter not less than six nor more than twelve inches deep.

Starting in the spring of 1882 with seventy-eight miles of dirt streets out of the total of ninety-three miles in the city, and the remaining fifteen miles old Telford-MacAdamized streets, which included all of the business streets, and the work of paving done since then has been as follows:

	Miles paved.	Cost.
In 1882	0·98	$31,137
In 1883	2·63	132,755
In 1884	9·03	442,167
Total	12·64	$606,059

We have taken up five and two-thirds miles of old MacAdam pavements and replaced it with stone or wood blocks.

	Miles.
There is now in the city, of old MacAdam pavement, about	9·3
Of new MacAdam	1·3
Of cedar block on concrete foundation	9·6
Of stone blocks on plank foundation	0·64
Of stone blocks on plank foundation	0·7
Of cedar blocks on sand foundation	0·4
Total paved streets	21·94

Permits are only given to parties who have obtained a proper license after filing a bond of $1,000 and depositing $25 in cash with the city treasurer, subject to the order of the city engineer. The conditions I have required of all parties who desire to make excavations in paved streets for gas, water, and sewer connections provide that the trenches shall be refilled with small broken stones, mixed with only moderate proportion of clay, put in and thoroughly rammed in twelve inch layers. The sides of the excavation at the top are sloped out and double the original thickness of concrete put in, and the blocks replaced in a workmanlike manner. A special inspector is employed for the purpose of securing good work. As a rule, this has been accomplished and the pavement restored to its original condition and without subsequent settlement. This is considered a very important matter, and the requirements are based upon the principle that no individual has the right to damage a street pavement if it is practicable to prevent it. The water works company, and the gas company have a general right to dig up the streets without legal restrictions, which is essentially wrong in principle, but practically, in this city, these companies have usually manifested a disposition to comply with proper requirements.

The general law of the city requires that railroad companies shall pave the space between the rails of all tracks, and a space of eighteen inches on the outside of each rail in the same manner as the roadway outside of such tracks may be paved.

Great difficulty has, however, been experienced in getting this work done right, and practically the paving done by the companies is of a very inferior kind.

THE MAROT TUNNEL.

THIS tunnel traverses, at an altitude of 700 feet, and at a maximum depth of 168 feet, the eminence called Marot, alongside of the Dordogne.

About two-thirds of it are excavated in calcareous rock, and one-third in marls and sands of the Tertiary formation (Pl. I., Fig. 3). During the preliminary operations the administration sank five shafts, the first and last of which corresponded to the external faces. Here, as in the Cabannes Tunnel, the galleries that spring from these shafts were excavated in the rocky parts; the work of excavating in the earth embraced a length of scarcely 26 feet. It was for this reason very difficult to obtain an accurate idea of what would occur while they were being finished, and, as we shall see, the uncertainty was greater than was allowable to suppose. Shaft No. 2, 164 feet in depth, caved in at about the time the contractors took possession of the works. This incident will not seem surprising when we add that, by reason of the bad nature of the earth traversed, the excavating had to be stopped at about 65 feet below the surface, and an aqueous stratum be diverted by means of a gallery parallel with the axis of the tunnel, and the execution of the shaft be continued by a second one parallel with the first. The drain of the up-stream excavation being finished, we found ourselves able to proceed with the headings through shafts Nos. 3, 3*bis*, and 4.

The portion comprised between the entrance and the point 54·5k. (Fig. 4, Pl. I.) for a length of about 2,100 feet consists of a tunnel through rock, and the work was attended with nothing remarkable except the meeting of a fault (54·232k.) having a length of about 23 feet. The passage through this portion was very difficult and expensive. During the preliminary work, the advance heading having cut this fault through its base, the clay soon began to move, and a large funnel formed on the surface of the soil, so that it became necessary to reduce the section of the gallery and line it with double planking. Before resuming the work of excavation, water infiltrated into the fault, and, as gravel had been used to fill the funnel that formed a drain, it resulted that the clayey sand, completely saturated by an immersion of more than a year, flowed through the interstices between the planking. The passage through this 23 feet took ten months of continuous work, during which there were taken out at least 70,500 cubic feet of material, representing an effective excavation of scarcely 650 feet.

Exploitation of the Rocky Portion.—This includes: (1) Excavation of the advance heading to 4¾ feet above the springing of the arch. (2) Widening the lateral parts. (3) Construction of the masonry arch. (4) Removal of the core. (5) Construction of the masonry facing of the lateral walls in the parts where the rock does not offer a sufficiently solid foundation for the arch.

These various phases in the construction of tunnels, being well known, do not merit any special description. We may remark, however, that it is well not to reduce the surface of the advance heading too much, and that an excavation of from 210 to 280 cubic feet seems preferable, in that it much facilitates the work of removing the excavated material and bringing in the supplies necessary for constructing the masonry. In the advance heading and its wings it is well not to give the shot holes a depth greater than 2 feet, and especially to charge them with caution, so as to avoid the destruction of the timbers through the projection of a part of the blocks formed. It will be readily seen, moreover, that with heavy blasts so much rock might be removed that it would be necessary to replace it with masonry. The removal of the *strass*, or surface comprised between the top of the wings and the floor of the tunnel, is effected in three stages, each corresponding to one or several shelves of rock. Fig. 3, Pl. II., shows the arrangement usually adopted. It is preferable not to give each shelf a height exceeding six feet, so that the escape of the chief miner may be facilitated after lighting the slow matches.

In the case of two banks or shelves the rubbish derived from the excavation of the upper one is carried away in cars running upon a track of 3¼ feet gauge. The next to the last car is set apart for this service, the rear one being designed to receive the material excavated from the lower bank, and the rest being employed in the widening out. In the case of three banks, 3 cars are employed in the heading, one of which is loaded by means of hand carts rolling first over a lateral shelf excavated for this purpose, and then over a plank arranged at right angles with the axis of the tunnel. The mode of loading the other cars is analogous. The lateral shelf is from 3¼ to 4 feet wide, and it often happens that it must be maintained back of the heading and be given a slight slope so as to connect the difference in levels between the top of the strass and the floor of the tunnel. In this case it serves as a roadway for the carriage of materials that have been let down through the shafts. When it is necessary to construct masonry walls, the following plan is preferable for excavating the rock at their proposed site: All the shot holes should be directed downward, with an inclination varying from 30° to 45°, the work being begun at the lower part of the proposed excavation. The first blast does not usually give a large cubage of broken stone, but, a cavity once formed, two new blasts almost always suffice to dislodge blocks for a height of nearly 10 feet.

In the wings, galleries, and the narrower mass of the core to the left of the trench, the drilling is done by means of a *burin*, a round tool, one inch in diameter and about 14 inches in length, terminating in a highly tempered steel point. This the workman holds in his left hand, and strikes upon the head with a mallet weighing about 4½ pounds.

In the greater mass of the core to the right of the trench the jumper is used. This tool is employed alone, and, as a consequence of its weight, allows the drilling to be performed much more easily and rapidly than in the former case. The wear of a burin per day is on an average ⅛ of an inch, and that of a jumper ⅛.

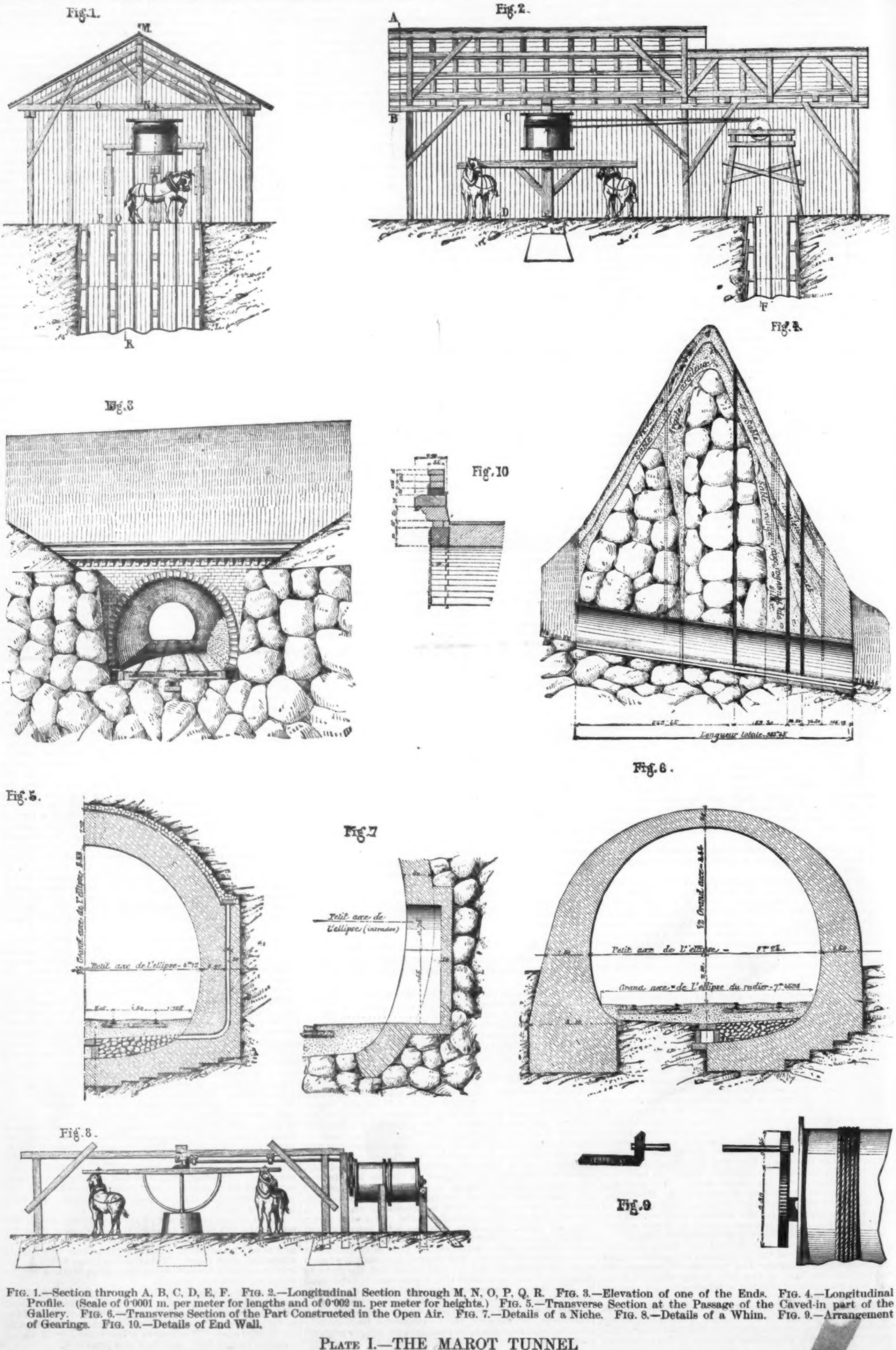


FIG. 1.—Section through A, B, C, D, E, F. FIG. 2.—Longitudinal Section through M, N, O, P, Q, R. FIG. 3.—Elevation of one of the Ends. FIG. 4.—Longitudinal Profile. (Scale of 0·0001 m. per meter for lengths and of 0·002 m. per meter for heights.) FIG. 5.—Transverse Section at the Passage of the Caved-in part of the Gallery. FIG. 6.—Transverse Section of the Part Constructed in the Open Air. FIG. 7.—Details of a Niche. FIG. 8.—Details of a Whim. FIG. 9.—Arrangement of Gearings. FIG. 10.—Details of End Wall.

PLATE I.—THE MAROT TUNNEL

We have employed dynamite in preference to powder, and we congratulate ourselves for the substitution. In the case of large shot holes, three 1,500 grain cartridges are sufficient to dislodge, and reduce to very small blocks, 28 to 35 cubic feet of rock. In the case of small shot holes, only one or two cartridges are used. The dynamite is fired by means of capsules containing 80 per cent. of fulminate of mercury and 20 per cent. of chlorate of potash, the latter being added to give consistency to the fulminate. Each capsule consists of 135 grains of the above mixture packed in a copper tube, closed at one extremity, and having sufficient length to allow of a free space of $\frac{3}{8}$ to $\frac{5}{8}$ of an inch, into which is introduced a Bickford slow match. This latter is cut by the miner in such a way as to give it sufficient length to project 4 or 5 inches from the hole. The cartridge is primed by opening one end of it and making a place for the capsule with a pointed stick. This done, the capsule is introduced, and the paper of the cartridge is wrapped around the slow match and tied with a string. In order to charge a shot hole, it is only necessary to introduce the cartridges one by one, reserving the primed one for the last. The whole is covered with clay carefully compressed with a wooden tamping bar. The slow match burns at the rate of 18 inches per minute.

In the rock, the thickness of the masonry lining is from 20 to 23 inches, and at the fault above mentioned has the arrangement shown in Fig. 5, Plate I.

Between the back of shaft No. 3 and the Brive mouth (of the project) the earth met with is entirely analogous to that found at the location of the Cabanes Tunnel, being exclusively formed of marl and immersed clayey sand that present serious difficulties.

In driving the galleries we met with no result with those running from shaft No. 3*bis*, since the miners had to encounter exceptional difficulties. At the extremity of each there occurred downfalls of rock that reached the surface of the earth and that the administration was unable to traverse. This being the case, we endeavored to get around them by driving intermediate shafts. Two attempts in this direction were made between shafts No. 3 and 3*bis*, but 3a^1 and 3a^2

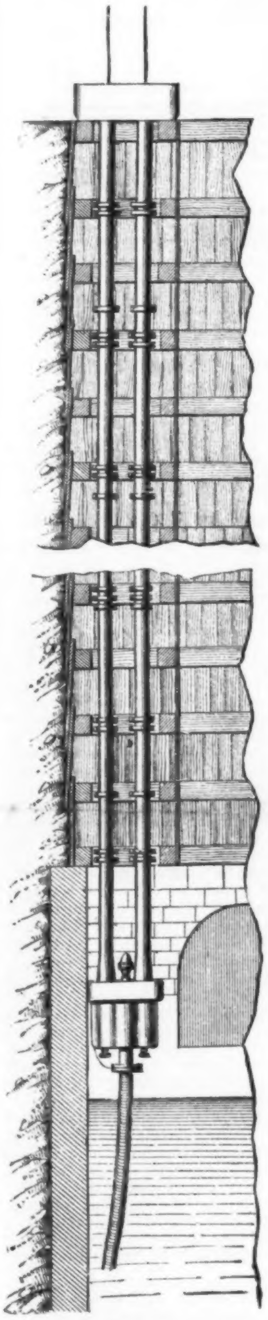


FIG 1.

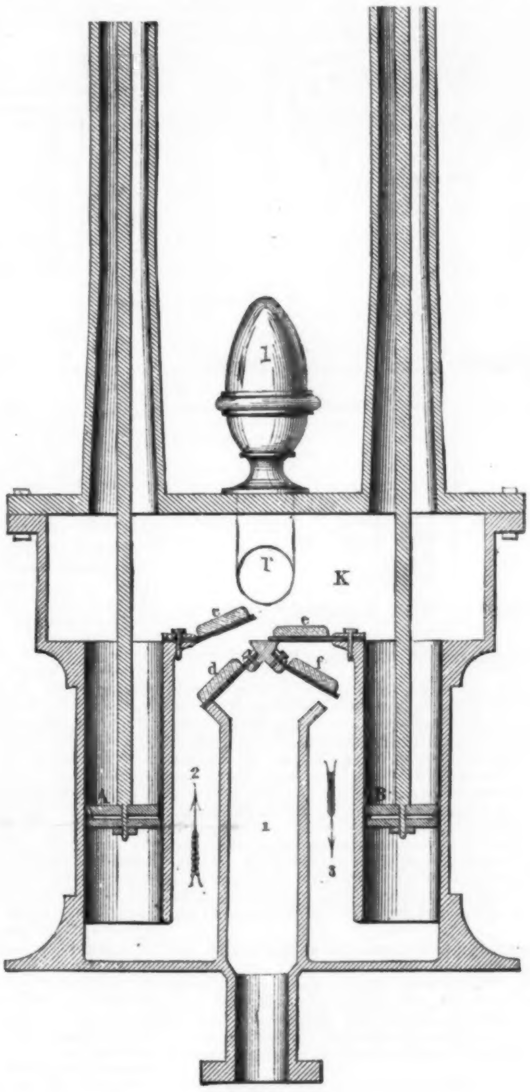
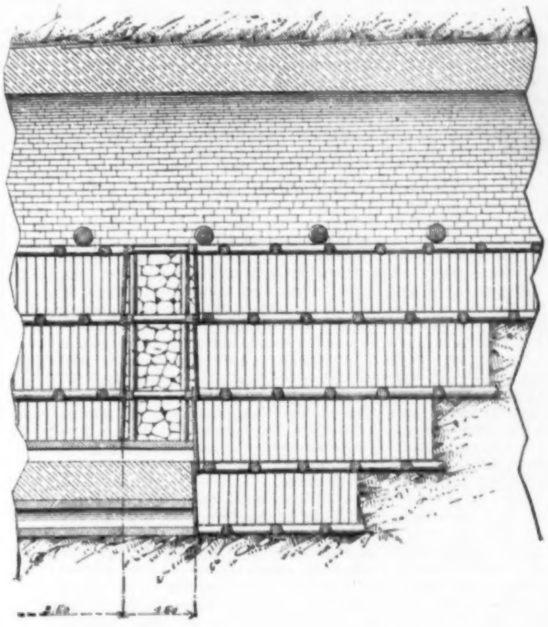


FIG. 2.



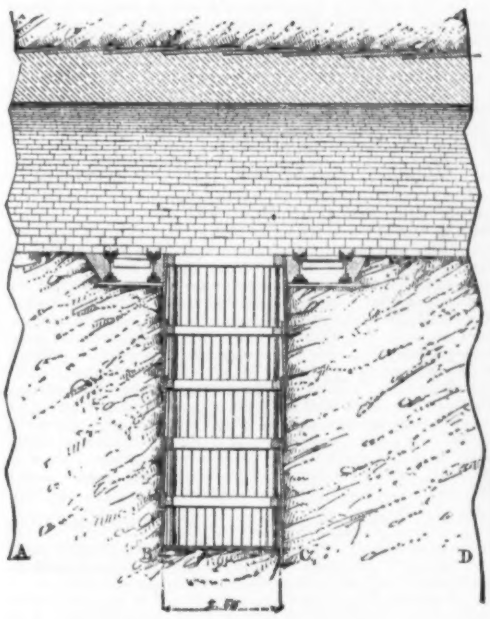
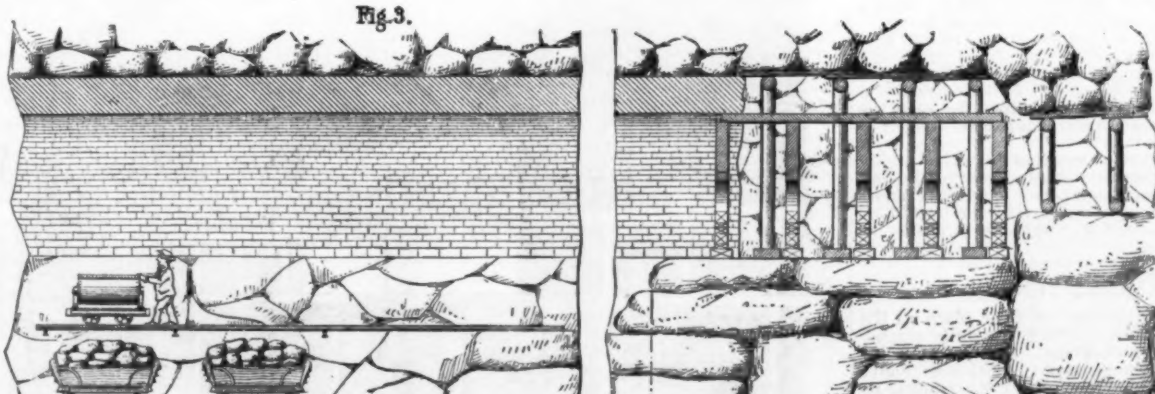


FIG. 4.

Fig. 3.



FIGS. 1 AND 2.—Details of the Griffon Pump. (Scale of $\frac{1}{50}$ for Fig. 1 and of $\frac{1}{10}$ for Fig. 2.) FIG. 3.—Mining the Rock by Shelves. (Scale of $\frac{1}{100}$.) FIG. 4.—Construction of the Walls and Floor in the Sandy Portions.

PLATE II.—THE MAROT TUNNEL.

caved in in succession when they had reached, one of them 27 and the other 33 feet.

The length of the galleries which are still to be driven at this point is 1,990 feet.

The attempt made between shafts No. 3*bis* and 4 was more fortunate, and shaft No. 3*ter*, which was quickly finished, permitted of driving the heading up to within 288 feet of the Brive mouth, so that there now remain less than 290 feet to pierce, about 110 of which are in the caved-in portion.

Finally, the part comprised between the back of shaft No. 4 and the Brive mouth, for a length of about 288 feet, is being constructed in the open air. The section given the masonry throughout this length is shown in Fig. 6, Pl. I., and the arrangement of the heads in Fig. 10 of the same plate.

The work of removing the rubbish required the following apparatus:

At well No. 1, a whim with vertical drum. At well No. 2, a 6 H.P. engine actuating a 2,640 pound windlass. At well No. 3, an 8 H.P. engine. At well No. 3 *bis* and 4, a windlass.

The Whims.—In the two whims the rotary motion is obtained through one or two horses. In the one with horizontal drum (Pl. I., Fig. 8) there is fixed to the shaft a wheel 2¾ feet in diameter, divided into 60 teeth which gear with those of a 38 toothed pinion 1¾ feet in diameter. The axle that supports this latter passes into three pillow blocks, and carries at its extremity a conical pinion that is actuated by a stiff cone wheel upon the lever to which the horses are harnessed. The respective diameters of these two latter wheels are 19 and 12 inches, and the number of teeth 44 and 26. The diameter of the lever being about 23 feet, the distance traveled is 61·80 feet. Granting that a horse makes 1·8 miles per hour, we obtain a velocity of 165 feet per minute, corresponding to 2·65 revolutions. When the lever has made one revolution, the two pinions have likewise described one circumference, and the wheel that drives the drum (granting a depth of 1 inch for the teeth) has made 1·07 revolutions. The diameter of the drum being 6½ feet, the circumference is about 20½, and the velocity of winding 58 feet per minute.

The Griffon Pump.—This pump has double pistons, whose maximum stroke is 7·8 inches. Its clacks are contained in a special chamber between the pistons. As a consequence of this arrangement, the weight of the water has no influence upon them. Each piston consists of two bronze disks between which is interposed a piece of leather. Under the effect of the downward pressure, the leather is pressed closely against the sides of the cylinder, and intercepts all communication between the upper and lower parts.

The result of this mode of construction is that the pump never has to be primed. As the pistons are fixed to their rods by means of a nut, it is easy to replace the leather whenever it becomes necessary. Finally, in a plane posterior to the pump chamber there is placed an air chamber, *l* (Fig. 2, Plate II.), which communicates with the box, K, through the conduit, I'. The object of this is to receive the air that might enter through the section pipe while the sump was being cleaned or the valves inspected, supposing that in such a case the ascension pipes were full of water.

As soon as the pump is started, the piston, A, rises, and produces a vacuum (Fig. 2). Under the influence of the pressure of the atmosphere the water rises in the suction pipe, lifts the clack, *d*, and passes into the conduit, 2. During this time the piston, B, is descending and compressing the air, which latter, lifting the valve, *e*, is forced into the box, K, and from thence into the ascension pipes. At the second movement communicated by the eccentrics, A descends and B rises. The first forces a certain quantity of air into the box, K, and the ascension pipes in lifting the valve, C, and the second produces a vacuum which is at once replaced by the water passing from the section pipe into the conduit, 3, in lifting the valve, *f*. The engines that actuate these pumps produce 100 strokes of the piston per minute, and set in motion two pulleys, one of which is loose upon the main shaft. As these pulleys are 26 inches in diameter, it results that the one fixed to the shaft describes $100 \times \pi \times 26 = 817$ feet per minute. The wheel that carries along the eccentrics is 6½ feet in diameter. It would describe $\frac{817}{20{\cdot}4} = 40$ revolutions, were there no loss resulting from the use of belts. Now practice demonstrates that such loss is approximately 5%; whence we may conclude that the wheel makes but 38 revolutions per minute.

Per piston stroke of 7·8 inches, $2 \times 2 \times \pi \times 7{\cdot}8 = 1{\cdot}73$ gallons: and for 38 strokes of each of them $2 \times 38 \times 1{\cdot}73 = 131{\cdot}48$ gallons. Now the discharge obtained being really only 91·66 gallons, it results that the performance corresponds to only 67% of the stress exerted. With a single piston the discharge is 2,640 gallons per hour.

We give the details of one of the pumps in Fig. 1 of Plate II.

As may be seen, the pipes are connected by lengths of 6½ feet. Each of them carries at its extremity a collar containing four holes for bolts. Between the collars of the two pipes is inserted a rubber washer, so as to make a tight joint.

This pump is capable of working in water highly charged with mud, detritus, or any floating bodies. On another hand, it requires a power of only six horses to discharge, at a height of more than 150 feet, 5,500 gallons per hour.—*Abstract of a paper by C. Muller in Ann. des Trav. Publics.*

THE CHANNEL TUNNEL.

Although no active operations take place at the Channel Tunnel, the works are very carefully attended by a regular staff of workmen. The whole of the machinery, with the exception of Colonel Beaumont's compressed air locomotive for use in the tunnel, remains on the works, and is kept in order, so that operations might be resumed at the shortest notice. The compressed air pumps are used twice or three times a week to enable an examination of the heading to be made, which to all appearance is in precisely the same condition as when the works were in full operation. The quantity of water which finds its way into the entire length of the heading, nearly three-quarters of a mile, is remarkably small.

Dr. Maitland Coffin, London, has successfully employed large doses of ammonia and chlorate of potash in the treatment of blood poisoning or puerperal fever.

DUCHAMP'S AERIAL SINGLE-RAIL RAILWAY.

We have several times spoken of Mr. Lartigue's ingenious single-rail railway, and, since this mechanism has been known in France, several American technical publications have recalled the fact that an analogous system was once patented in the United States for running passenger cars upon. The first invention, then, belongs to Young America. All right! We are now going to show that, before that American enterprise, one of our fellow countrymen, Mr. Duchamp, had constructed at Lyons, at the time of the Exhibition (1872), a very curious system of aerial single-rail railway. The first idea of such a structure belongs, then, to old France—unless our learned collaborator, Mr. De Rochas, shall some day find it in the memoirs of Heron of Alexandria!

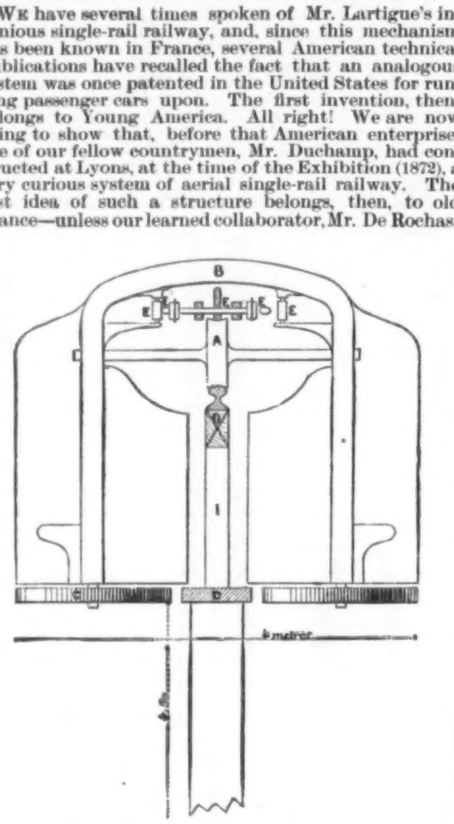


Fig. 2.—SECTION OF THE RAILWAY AND CAR.

Mr. Duchamp's railway is a very well studied and well conceived work, which in no wise detracts from the merits of Mr. Lartigue's construction, and is well worthy of being described as an interesting scientific conception. Fig. 1 gives a general view of it, and shows its general arrangement. The length of the line was about one kilometer (1,100 meters exactly). The single rail was supported here and there by posts planted in the earth. These posts, which were of wood, were 4·5 meters in height. On top of them there was a lateral wooden rail, D (Fig. 2), that formed a guide on either side. Above this there was a bar of iron, I, which was affixed by a flange to the wooden guide, and which carried at its upper extremity a wooden stringer that supported the rail.

The car consisted of two symmetrical parts, and was suspended from the rail by two pulleys, one in front and one behind. Thus placed, the car was in equilibrium only when the load was perceptibly the same on each side. The inventor remedied this trouble by placing beneath the car a horizontal pulley, C, which, every time the equilibrium was destroyed, rubbed against the guide rail, D.

Each car had seating accommodations for thirty travelers on benches that ran longitudinally through the car and faced the exterior. The train was made up of two cars, which were coupled in the ordinary manner. The fare was 10 centimes, and the daily receipts exceeded 350 francs. The motive apparatus was an endless cable which ran around two horizontal drums, one at one end and the other at the other end of the line. One of these drums was actuated by an 8 H.P. steam engine; but the actual power used was but two or three horse. The cable was of hemp, and was 2,200 meters in length. It traversed the cars longitudinally, and, when the latter were at a standstill, it simply slid upon the rollers, E. When the train was to be started, it was only necessary to grip that portion of the rope that was running in the desired direction.

Mr. Duchamp's gripping arrangement was as follows: As shown in the plan in Fig. 3, there were four fixed pulleys and three movable ones, and the latter could be made to approach or recede from the former by means of a pressure screw, F. There were two series of rollers—one for running forward and the other for returning—and these were so arranged that but one portion of the rope could be gripped at a time. When the cable was strongly gripped between these quincuncially arranged rollers, the car was carried along. On arriving at the end of the route, it was only

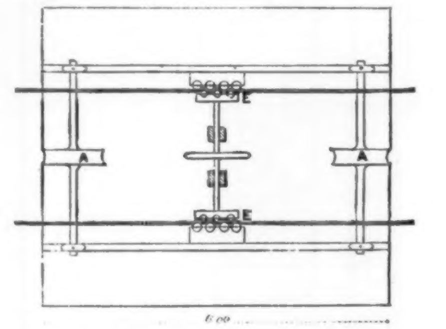


Fig. 3.—GRIPPING ARRANGEMENT.

necessary to grip the other portion of the rope to return again to the starting point. When it became necessary to stop on the way, the conductor gripped the portion of the rope that was running in the opposite direction.—*La Nature.*

COMPLETION OF WASHINGTON MONUMENT.

The long expected completion of the Washington Monument obelisk was accomplished on December 6, 1884, by the setting in place of a marble capstone and its pyramidal apex of aluminum. The ceremonies were few and simple, an elaborate celebration of the event being reserved for Washington's birthday. Shortly after 2 o'clock Col. Thos. L. Casey, Government Engineer-in-charge, and his assistants, Capt. Davis, United States Army, and Bernard R. Green, civil engineer, together with Master Mechanic McLaughlin and several workmen, standing on a narrow platform built around the stopped marble roof near the summit, proceeded to set the capstone, weighing 3,300 pounds, which was suspended from a quadripod of heavy joists supported by the platform and towering forty feet above them. As soon as the capstone was set, the American flag was unfurled overhead, and a salute of twenty-one guns fired by a battery in the White House lot far below, the sound of cheers also came up faintly from a crowd of spectators gathered around the base of the monument, while a number of invited guests were on the 500 foot platform, and on the interior of the foot of the monument at that level spontaneously struck up "The Star Spangled Banner" and other patriotic songs. A steady downpour of rain had given place a little while previously to a brisk gale of wind which, at this elevation, was blowing about fifty-five miles an hour, and very few invited guests cared to avail themselves of the privileges of climbing the nearly perpendicular ladder from the 500 foot platform to the dizzy height of 533 feet, from which three or four journalists and half a dozen other adventurers climbed and witnessed the setting of the capstone, and subsequently ascended to its pinnacle.

Meanwhile the Washington Monument Society, represented by Dr. Joseph M. Toner, Hon. Horatio King, Gen. William McKee Dunn, Dr. Daniel B. Clark, and T. L. Harvey, secretary, held a meeting on the elevated platform at a height of eight feet, and when the artillery firing announced the setting of the capstone, adopted a resolution offered by General Dunn congratulating the American people on the completion of this enduring monument of our nation's gratitude to the father of his country.

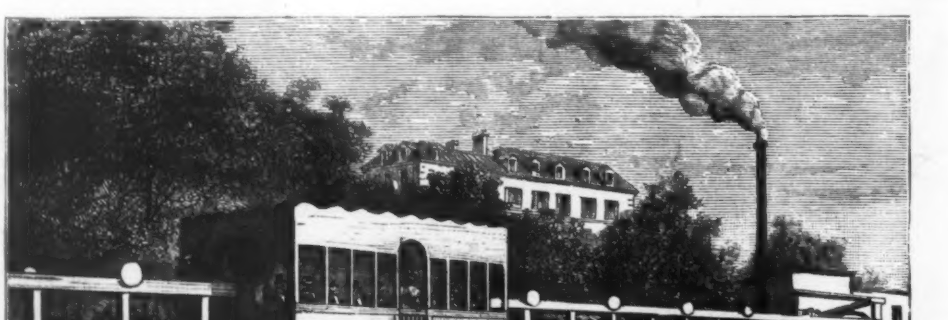


Fig. 1.—DUCHAMP'S SINGLE RAIL RAILWAY.

Among those present to-day at the completion of the structure was one of the master mechanics who laid the corner-stone of this monument more than thirty-six years ago, and the old watchman of the monument who has been continuously employed in that capacity during nearly the whole intervening period. The flag over the monument floated to-day from the flagstaff-top, which is exactly 600 feet from the ground, thus displaying the American colors at the greatest height ever known in the world. The monument itself, with its height of 550 feet, far overtops every other structure of human hands. The aluminum apex of the monument is engraved with inscriptions, as follows:

On one face, "Chief Engineer and Architect, Thos. Lincoln Casey, Colonel Corps of Engineers. Assistants, Geo. W. Davis, Fourteenth United States Infantry; Bernard R. Green, Civil Engineer; Master Mechanic, P. H. McLaughlin."

On another: "Corner-stone laid on the bed of the foundation, July 4, 1848. The first stone at a height of 152 feet, laid August 7, 1880. Capstone set December 6, 1884."

On a third: "Joint commission at the setting of the capstone, Chester A. Arthur, W. W. Corcoran, and Chairman M. E. Bell, Edward Clark, John Newton, Act of August 2, 1876."

And on the fourth face the words: "Laus Deo."

The capstone is a cuneiform keystone, four feet five and three-quarter inches on the outer faces in height, with a shoulder on each side of seven inches to tie the ashlar face of the pyramidal cap; below this shoulder the stone is ten and a half inches, making the total length from top to base five feet two and a half inches. The stone at the base is three feet nineteen-seventeenths inches square, and at the cap where the aluminum tip is to be placed, the diameter is exactly five inches.

The aluminum tip is something new in monumental architecture, and its use is for two purposes. It is freer from oxidation than any other substance that could be used, and it is of exceptional value as a conductor of electricity, serving in this case as the tip of both monument and the lightning-rod. It will be secured in its place by a wrought copper rod, leading down through the center of the capstone, and below will connect with each of the four columns that form the elevator frame in the main shaft. At the base of the monument, these leaders will be conducted to the well beneath the center of the foundation, thus forming the most perfect electrical conductor known to science.

The capstone was set by the following means:

Beginning a few feet above the main shaft, on each of the four sides of the pyramid four heavy joists are placed, and on these, thirty-three feet above, is built a platform extending around the cap. Extending up from this platform are four joists, one at each corner of the structure, which meet forty feet above and support a tackle with which the remaining stones are handled. To the point where the platform is built all the stones of the pyramid were handled with the mast and boom that extended from the interior framework, but as the cone narrowed the spar was removed and the outside frame built. Before this, however, all the remaining stones were hoisted to the platform and handled from there. When the capstone is set this afternoon and the tip placed in position and fastened to the copper rods below, the upper joists will be removed and lowered by the men, and as the platform and its supporting-frame is taken away and lowered, the remaining men will work from a temporary platform hung from skids or joists projecting from the window, which has been cut in the east face of the last course below the cap. This window is three feet long and two feet wide, and after the last timber has been lowered and the last man has entered the pyramid the hole will be closed by a stone, which accurately fits, and cemented in place. The lower platform and the guard-netting at the 500-foot level will be removed through the hole at the base of the pyramid, which was left to pass the upper stones outside from the elevator. When this is done the stones belonging there will be set and the whole structure from foundation to the aluminum tip will present an unbroken appearance. The narrow windows in each face of the pyramid, which are four feet above the 500-foot landing, will be fitted with heavy marble shutters, which are to be worked by ingenious machinery inside. These windows, which seem like tiny streaks from the ground, are each three feet long and eighteen inches high, and are eight in number, two on each face, giving a perfect view of the surroundings.

The corner-stone of the monument was laid with imposing ceremonies July 4, 1848, and the work for several years was paid for with money derived from popular subscriptions. The source, however, soon failed, and after about $200,000 had been expended the work ceased, and during the years that elapsed from 1852 until 1859 the unfinished shaft (which resembled more the white-washed chimney of a huge factory) was the nation's disgrace. Finally on Independence day of the Centennial year, Senator Sherman presented a resolution declaring it to be the sense of Congress that the monument should be completed. The resolution and the necessary appropriation to begin the work anew was passed by both houses unanimously, and since then the work has progressed steadily.

In 1876 the monument had reached the height of 152 feet above the foundation, and about $260,000 had been expended on its construction; $900,000 has been expended under appropriations of Congress. The corner-stone, which was cut from the same ledge of marble (near Cockeyeville, Md.), from which the marble of the shaft has been taken, weighed a little more than twelve tons, and was laid at the northeast corner of the foundation.

Very soon after the appropriation of 1876 became available, Colonel (then Lieutenant Colonel) Thomas Lincoln Casey, corps of engineers, U. S. A., was designated by President Grant, through Secretary of War McCrary, as the engineer officer to conduct the work, and Captain George W. Davis, 14th U. S. infantry, was ordered here from Texas and placed on special duty as an acting engineer officer, as assistant for the monument construction.

The first work done was in 1877, when shafts were sunk at different points about the monolith and borings made to find the character of the strata below the foundation. It had already been ascertained that the original foundation extended only five feet below the surrounding earth's surface, while fourteen feet reached above the floor of the shaft. The examinations showed that below the old foundation was a series of layers of yellow and blue clay on a rock stratum, sloping away to the original bed of the adjoining Potomac, and that these beds of clay were thickly strewn with huge bowlders of the ice-period. The clay taken out was tested for compressibility, but the examinations and tests showed that, to contain the huge structure of over 81,000 tons, the foundation should rest upon the bed-rock, still fifteen feet below. These examinations and the studies of the subject made by Captain Davis continued until 1878, when finally the plan of building a new foundation beneath the old one was decided upon, to the astonishment of engineers all over the civilized world. How such a thing could be done was the wonder until Colonel Casey and Captain Davis practically demonstrated it by accomplishing the fact.

The old foundation was so ridiculously shallow and narrow in base that the addition of the weight necessary to carry out the design of height would have sunk the structure into the ground, much like thrusting a cane into moist earth, or more likely, have toppled it over toward the adjacent Potomac flats. A new and wide foundation was built under the old one and resting on the bedrock beneath. The magnitude of this before unheard-of feat of engineering was so great that home and foreign civil engineers visited the work to see for themselves that it was actually being done. The complete work of the sub-foundation is one of the greatest feats of engineering known in the world.

Meantime, while the foundation examination had progressed, means had been found to reach and examine the top which was left unfinished before Congress took action. The three upper courses of stone, each one two feet high, were found to be so damaged by the action of frost, and perhaps lightning, that they were removed before the work on top was resumed at the exact height of 150 feet.

September 11, 1878, an inspector of the proposed work and Mr. P. H. McLaughlin reported at the monument grounds, and were followed the next day by a small gang of carpenters, of which Mr. McLaughlin was then the foreman, who began the erection of the necessary buildings. The first superintendent, who reported in

THE WALLACE STATUE, ABERDEEN.

the same month, was Mr. Navarre, and on his resignation in 1879 Mr. McLaughlin was promoted from master carpenter to succeed him.

August 7, 1880, the first stone above 150 feet from the foundation was laid, and to this date Mr. McLaughlin has superintended the whole of the work.

Since the commencement of work on this monument the States of California, Oregon, Minnesota, Kansas, Nevada, Nebraska, and Colorado have been admitted into the Union, we have chronicled the history of nine political administrations, witnessed the birth and death of political parties, and passed through a terrible civil war and four financial strains, and established the best banking system in the world. The great republic in the meantime has grown from 23,000,000 to 55,000,000 people, and in material wealth from $7,400,000,000, or $320 per inhabitant, to $57,000,000,000, or about $1,000 per inhabitant. When the National Monument was begun Great Britain possessed five times the wealth owned by the United States, and while the wealth of the former country has only doubled within the past four decades, that of the latter has increased twelve-fold. As to the constituent factors of American progress in their aggregate in the four decades they are sufficient to buy up the whole Austrian Empire several times over, or pay for the aggregate value of the "effete" monarchies of Italy, Holland, and Belgium almost three times over during that period. Our tilled acreage has increased from 50,000,000, o 170,000,000 acres, the crops have increased in value from $415,000,000 to $2,500,000,000, and the cattle have increased in value from $380,000,000 to $18,400,000,000. Our imports have increased from $178,000,000 to $668,000,000, and our exports from $152,000,000 to $836,000,000.

The work is by no means completed now, for it will take many months, and perhaps several years, to complete the pedestal and finish up the surroundings.

The joint commission in charge of the monument has recently submitted to Congress a report showing its progress during the past year. The report shows the weight of the monument is 81,120 tons, and it has cost $1,187,710, of which Congress appropriated $887,710. In relation to the completion of the monument the engineer in charge of the work submitted a report with that of the commission. He says: "Two methods of treating the terrace at the foot of the shaft have been suggested. One method proposes to erect a retaining wall of the most beautiful marble around the terrace, which wall is to be surmounted with marble balustrade. At the center of each face is to be set off broad double stairs extending from the general level of the esplanade, which is to be paved with marble tiles of approved patterns. The other method of finish proposed is to fill earth about the present terrace, and extend this filling as far from the monument as to fade the slopes of the embankment gradually into the surrounding surfaces, and this is to be done with so much skill as to give the mound an appearance as far from artificial as possible. This mound is then to be planted with trees and shrubs, and paths are to be laid out. A pavement is to be put around the foot of the mound, far enough to prevent storm waters from washing out the filling. If the marble wall is decided upon, an appropriation of $612,300 is asked to complete the entire work. If the second proposition is adopted, but $166,800 is desired." The joint commission favor the latter method.—*Kansas City Review.*

THE WALLACE STATUE, ABERDEEN.

WE give herewith, from an original drawing by Mr. W. Grant Stevenson, an illustration of the statue of Sir William Wallace which is about to be erected at Aberdeen. It will be remembered that some time since competitive designs having been called for, twenty-five sculptors entered the lists; and from their models, forwarded to Aberdeen about three months ago, the trustees, aided by the advice of Sir Noel Paton, R.S.A., and Dr. Rowand Anderson, architect, selected three, which their respective authors were requested to revise with reference to costume and other details. The three thus chosen were, besides Mr. Stevenson, Mr. J. Whitehead, London, and Mr. Warrington Wood, London. The revised designs, distinguished by mottoes, having been consigned to the care of Messrs. Doig and McKechnie, Edinburgh, were lately inspected in the saloon of that firm by the trustees and their artistic assessors, when the final decision was given in favor of Mr. Stevenson's. Wallace is represented as standing on a rock; the figure being firmly poised on the right leg and the left foot well advanced, planted on a raised projection. The head is bared, the hair being blown back as if by a fresh breeze; and the animated expression of the features corresponds with the action of the outstretched left arm in emphasizing the declaration, which the champion is supposed to be making to the English ambassadors, that his purpose is not to treat, but to fight for Scotland's freedom. The right hand holds the huge sword, whose blade, forming a diagonal line across the body, seems to bar the enemy's advance. In the absence of any authentic portrait, the head is partly ideal, partly formed on descriptions of the hero's appearance. The costume, which has been studied from carved work of the period, consists of chain armor under a tunic, which is girt round the middle by the combined waist and sword belt. A cloak falling from the shoulders and partially covering the left arm affords opportunities for effective disposition of light and shade. The statue is to be cast in bronze on the colossal scale of 16 ft., and will be the largest work of the kind in Scotland.—*Building News.*

[AMERICAN ARCHITECT.]

ROOFING-TILES.

THERE is no way to tell exactly at what time the art of making roofing-tiles was revived in England. But as the buildings of the Anglo-Saxons were usually of wood, rarely of stone until the eleventh century, and as the first instance of a modern or Flemish brick building in England does not occur until after the first half of the thirteenth century, it is not probable that roofing-tiles were made prior to building bricks.

We have been making building bricks extensively in the United States for more than three-quarters of a century; but it is only within the past few years that we have accomplished anything in the line of manufacturing roofing-tiles. The following statement in this connection is, of course, purely hypothetical; but we probably state the truth when we say that England has probably never discounted us, and made roofing-tiles before she made building bricks.

In 1784, tiles as well as bricks were subjected to taxation by George III., which burden lasted for two-thirds of a century, not being repealed until 1850.

The plain tiles now in general use in England weigh from two to two and one-half pounds each, and expose about one-half their surface to the weather, four hundred of them covering "a square," or one hundred superficial feet of roof-surface; they are sometimes hung upon the sheathing-board by two oak pins inserted through holes left by the moulder. Plain tiles are also now made with grooves and fillets on the edges, so that they can be laid without overlapping the usual distance, the grooves leading the water. This may answer for some cheap constructions where lightness is also a consideration; but the plan is a bad one, as they will be certain to leak in the driving rains and drifting snows, and they are also, if not very thoroughly burned, subject to injury by hard frosts.

Pantiles were first used in Flanders, the wavy surface lapping under and being overlapped by the adjacent tiles. The English pantiles weigh fron five to five and one-quarter pounds, expose ten inches to the weather, and one hundred and seventy-five of them cover a square, or one hundred superficial feet of roof-surface. Modifications of the pantiles have been made in which the central portion is flat, and the edges turn up and down respectively.

In England a gutter-tile is sometimes used, and forms the lower course, overhanging the lower sheathing board or lath, and is nailed to it.

Sliding tiles are used in this country and in Europe sometimes as a substitute for weather-boarding; holes are made in the tiles during moulding, and they are secured by flat-headed nails to the lath. The exposed face of these tiles, called the gauge, is sometimes indented to represent courses of brick; fine lime mortar is introduced between them, when they rest one upon the other. Tiles of this character are sometimes called weather-tiles, and sometimes mathematical tiles, the names being derived from their exposure or marking. They have a great variety of forms, having curved or

crenated edges, and are also variously ornamented with raised or encaustic figures.

Roofing-tiles were probably used in Normandy before being employed in England, as the latter country always followed in the wake of its more energetic neighbors in all matters relating to architectural progress. All the rich Norman mouldings were copied by the English, and, as a great part of the knowledge of the art of manufacturing decorative tiles was derived from the Normans, it is not improbable that they are also indebted to them for a knowledge of the manufacture of roofing-tiles. The Normans were an active race, and delighted in building; to dwell in and constantly beautify their magnificent castles seems to have been the delight and greatest pleasure of their princes and nobles. But of course no credit is due to the Normans for having originated the use of roofing-tiles, as they had been employed in the East, and the art of their manufacture was borrowed by the crusaders. The highly ornamental buildings of Byzantium, Palestine, and Syria were very attractive to the crusaders, and as many of the early Norman roofing-tiles correspond with features of Byzantine architecture, the analogy is a corroboration of the statement previously made.

When roof-tiles are to be glazed, they are sometimes varnished after being burned; the glaze is then put on, and the tiles are placed in a potter's oven, and remain until the glaze commences to run. The glaze is usually made from what we call lead ashes, being lead melted, and stirred with a ladle till it is reduced to ashes or dross, which is then sifted and the refuse ground on a stone and resifted. This is mixed with pounded calcined flints. Manganese is sometimes employed to produce a glaze, which is usually of a smoke-brown color. Iron-filings are also used for producing a black color; for green, copper slag; and for blue, smalt is employed, the tile being first wetted and the composition laid on from a sieve. Cheap salt glaze can also be applied to tiles in the same manner as for earthenware sewer-pipes.

Before proceeding to describe the method of manufacturing roofing-tiles we will first consider some of the advantages which accrue from their employment. Tiles when well made and thoroughly burned are indestructible, and are not affected by heat and cold. They will not crack and slide off the roof like slate, leaving the sheathing exposed, when subjected to sudden heat, as by the burning of an adjoining building. In addition to the fact that after doing service on one structure the tile can be taken off, and used on other buildings, there is the picturesque appearance which modern tile-covered roofs add to the architectural effect. Another great advantage for the tile-roof is that it is a non-conductor, and, therefore, cooler in the summer season than other roofs; the buff tile being lighter in color is preferable in the latter respect, as it does not absorb the rays of the sun. A final advantage, which, although we mention it last, is of paramount importance where cisterns are employed, is that the rain-water collected from a tile-roof is much purer and more healthful than from any other kind of roof, as the tiles are very smooth, and no dust or soot settles upon them.

Objections to roofing-tiles in this country have heretofore been made that the tile was heavy, made of coarse clay, poorly burned, and that it would absorb a great amount of moisture, so that freezing and thawing would cause it to crumble, and in appearance it was anything but handsome. Whatever foundation these objections may have had in the first product of tiles, our manufacturers have now fully met and remedied these drawbacks to their use.

Tiles should not be put upon a roof that has less than one-quarter pitch (a slant of six inches to the foot), although we have seen some roofs of less pitch which have proved quite satisfactory. A roof to support tile should be somewhat stronger than for shingles. Rafters 2" x 6", spaced 18 inches apart and well stayed so that they cannot spread, form a good frame. The sheathing should be of white pine, of even thickness, and close together. Generally, felt or tarred paper is placed under the tile, although it is not necessary to make the roof water-tight, but it impedes circulation and makes the roof warmer in winter, and adds but little to the cost.

When the process of manufacturing roofing-tiles is conducted by hand, the method is about the same in the United States as in England, and but few improvements have been made in this mode of production during the past century; but by the machine process we are enabled to manufacture very satisfactory roofing-tiles at but a small cost when compared with the hand method of moulding. The clay of which the tiles are made is dug and spread out in shallow beds to disintegrate during the winter season, the water contained in the clay expanding and breaking it in every direction. At one time very inferior roof-tiles were made in England, on account of the careless weathering or preparation of the clay employed; and in order to cure this, a statue of Edward IV. required that all clay for tiles should be dug or cast up before the first of November, and not made into tiles before the March following. Sometimes when the clay has not been exposed to the frost it can be disintegrated by spreading it out in thin layers, and exposing it to a hot sun.

Iron rolls are often employed to disintegrate the clay, and crush or separate from it all stones and gravel. The clay must next be tempered, that is, reduced to a homogeneous and plastic mass. The usual form of pug-mill employed in England for tempering clay for roofing-tiles is generally six feet high, three feet in diameter at the larger or upper end, and two feet at the bottom. The clay is kneaded and thoroughly mixed by a revolving cast-iron spindle, which carries a series of flat steel arms, so arranged as to have by rotation a worm-like action upon the clay, which is pressed from the larger to the smaller diameter of the tub in which the clay is confined, and finally comes oozing out of an aperture at the bottom; in this manner of tempering, great cohesive power is given to the clay. After it issues from the bottom of the pug-mill, the clay is usually ready to be moulded into roofing-tiles, the moulding is commonly conducted in a shed, and most of the manufacturers prefer to place their tiles in the open air, if the weather allows.

The moulding-table or bench upon which the tiles are shaped is supported on four legs, which are placed well under the bench, leaving the two ends of the top of the table to project liberally. The coal-dust box, 14" x 8", is at the left hand of the moulder, resting on the corner of the table, and the moulding-board, 14" x 10", is usually placed slightly to the right of the coal-dust box. The mould employed is 12" x 7¾", and one-half inch thick, made of oak, and usually plated with iron. The moulder, when he wishes to form a tile, works a lump of clay with his hands into an oblong square, the mould is placed on the bench, and fine coal-dust sprinkled over it; the lump of clay is then taken up and dashed down into the mould with force, the surplus clay is cut off level with the top of the mould by a brass wire strained upon a wooden bow, and the tile in the mould is finished by adding a little clay to it, if necessary, and smoothing the exposed face with a wooden tool. The moulded tile is then placed upon a thin board, first sprinkled with very fine coal-dust, and so the process is repeated, the lump of clay being added to every time six tiles are moulded.

The boy or off-bearer carries two tiles at a time, one on his head and one on his hands, to the floor, where they are allowed to remain for four hours out of doors in fair weather, and then collected and placed together, the nib end changed alternately, so as to hack them closely and squarely. The situation of this hacking should be dry, but not hot, and the tiles remain hacked for two days, so as to allow them to toughen.

The set or curve form is then given by placing six of the tiles at one time on the top of the horse, which is a three-legged stool, having the top about three-quarters of an inch longer than the tile, the top being a convex curve to a radius of about ten feet and three inches, and having a height of about two feet and seven inches from the level of the ground. In placing the tiles on top of the horse, the nib end is reversed each time, and as they lie closely together, three quick blows are given to the tiles with a block, which is concave, so as to correspond with the convexity of the horse. The tiles are then again hacked and dried, and next carried to the oven, twelve at a time, with the edges of the tiles resting against the breast of the carrier.

About nine thousand tiles are commonly burned at one time, when the old-fashioned Staffordshire oven is employed; but with larger kilns the quantity of course can be increased. The time required to burn the small ovens of tiles is usually about from thirty-six to forty hours.

The manufacture of plain roofing-tiles such as we have described can be conducted with a small capital, the process and requirements not being intricate or expensive. But to conduct the manufacture of all the tiles required for roofing, and the numerous other articles generally made in large tileries, requires a large capital and a thorough knowledge of the business in all its details. To faithfully describe the manufacture of all the articles produced in extensive tileries would increase this paper to such an extent as to fill a large volume; the principle of procedure is the same in each case, but no two different articles are made or finished in a similar way, each requiring different tools and moulds.

In the London tileries, which are the largest in the world, there is paid particular attention to the proper preparation of the clay for the particular purpose for which it is to be used; there not being the same haste to get the clay into the kiln that is so often shown by some of the smaller manufacturers. The first step in preparing the clay in the London tileries is the weathering, which is accomplished by throwing the clay into pits covered with water, and leaving it to soften or ripen. The clay is then usually passed through the rollers, and the stones taken out before it is put into soak, which is a term also used for the mellowing process. The kilns used for burning the wares produced in these extensive London tileries are usually conical in shape for more than one-half the height, about forty feet wide at the base, and have a total height of about twenty-five feet from the bottom of the ash-pit to the top of the dome, which is slightly convex. These kilns are quite expensive to construct, eight thousand dollars being about a fair average cost, as fire-bricks of the best quality are largely employed in the interiors.

The manufacture of roofing-tiles is a comparative new industry in the United States; but it is one which is now rapidly growing in public favor. With us, the tiles are usually of three colors—red, buff, and black. The color of the red tile is produced by the employment of clay containing a large percentage of oxide of iron; this is sometimes present in the beds with fire-clays, which are the class usually employed for roofing-tiles; at other times, it is necessary to mix some foreign clay, containing a large percentage of oxide of iron, the material. The color is made deeper and more uniform by rubbing the tiles with finely-sifted red moulding sand; this should be done while the tile is quite damp, so that the sand can be made to adhere to the tile. The buff-colored tile is made of nearly pure fire-clay, and is slightly lighter in weight than the red tile. The black-colored tile is produced by washing it over with manganese dissolved in water before the tile is placed in the kiln, and in the process of burning the manganese is converted into a perfectly durable coating of great hardness.

The small diamond tiles are 6" x 10", require 500 to cover a "square," and weigh 600 pounds. They are nailed to the sheathing with two five-penny galvanized nails, and are used more especially for towers, porches, dormer-windows, and inside panels for ornamental purposes.

Large diamond tiles are 14" x 8¼", 250 cover a "square," and weigh 650 pounds. Two six-penny galvanized nails are used to secure it to the sheathing. This kind of tile is used more than the other forms for regular roofs, as it is lighter in weight, and less in cost.

The shingle tiles are the plain flat tiles, the manufacture of which we have described in this paper; after burning they are three-eighths of an inch thick, have two countersunk nail holes, and can be made of any required size not exceeding 6" x 12"; they can be obtained from the manufacturers, who keep them in stock. Tiles have been largely employed in the Eastern States, and on some expensive buildings, for roofing and side-ornamentation, as at the State capitol at Albany, N. Y., on which building they are secured with copper wire to iron ribs. Tiles of this kind are generally laid so as to expose about five inches to the weather, which require 480 to a "square," the weight being about 1,100 pounds.

The pantiles measure twelve inches in length, by six and one-half inches in width at one end, and four and one-half inches at the other, and if they are lapped three and one-half inches on the roof, 350 will be required for a "square," which will weigh 850 pounds. This kind of tile makes a strong roof cover, and can be walked upon without danger of breaking, and it is especially suitable for workshops and factories; it is sometimes made with lugs to hang on to ribs, the use of nails being thereby avoided, which is desirable, as nails are liable to rust away where much bituminous coal is used. But the tiles are also made with nail holes to secure them to the sheathing-boards, as for private dwellings, etc.

The varieties of tiles which we have just described are made at Akron, O., in large quantities, and are shipped to all parts of the United States. In England and other portions of Europe, roofing-tiles are mostly made by the hand method; but in our country they are almost entirely produced by machinery.

The crestings and finials used with tile require artistic treatment, and are generally made by manufacturers of terra-cotta.

CHARLES T. DAVIS.

FIREPROOF FIXING BLOCKS.

THE disadvantages attending the various methods of securing joiners' work to walls have at various times presented themselves to most architects. Wood as a fixing material is liable to rot, to shrink and become

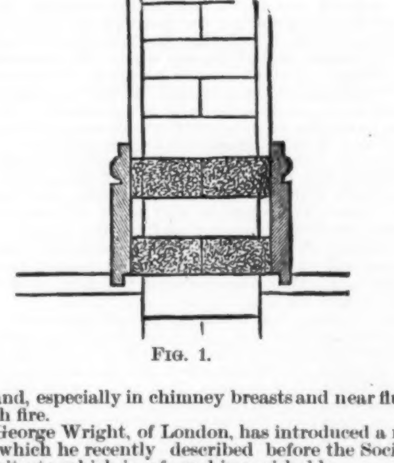


FIG. 1.

loose, and, especially in chimney breasts and near flues, to catch fire.

Mr. George Wright, of London, has introduced a material, which he recently described before the Society of Architects, which is safe and imperishable.

The fixing blocks are fireproof, as hard and everlasting as brick or stone, yet of such a nature that nails can always be driven into them. Being made about the same size as ordinary bricks, they are built into reveals of openings, jambs, etc., without the slightest extra labor or trouble to the bricklayer, and without destroying the bond of the work. When in position, the blocks at once form a fixing for the wood linings, architraves, etc., and which become in reality fixed to the solid wall, dispensing entirely with the wood joint pieces, strips, etc., which shrink, and frequently require wedging up before a set of linings can be fixed. Driving plugs, and consequent injury to walls, is entirely obviated by using these fireproof blocks. They can also be safely inserted near fireplaces and flues, and for fixing bell pulls upon chimney breasts, without the slightest risk of taking fire—a great advantage over wood plugs, which in these positions are a source of danger.

Another application of these fireproof blocks does away with the necessity of putting skirting chocks into, and wood skirting grounds upon, walls. (See Fig. 1.) They are made for this purpose about ¾ in. wider than ordinary bricks, offering for the plastering a similar, but (from the affinity of the respective materials) a better key than that obtained when using the wood ground. This size of block may also be used with great advantage when walls are to be boarded, as in dadoes, wall linings, match boardings, etc. (see Fig. 2), or

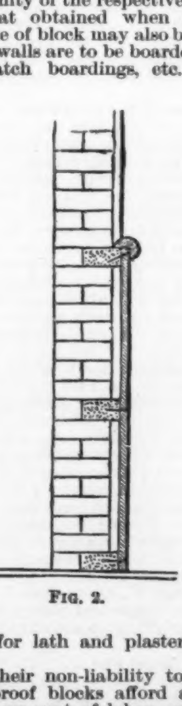


FIG. 2.

where battened for lath and plaster, slate, or tile-hanging, etc.

In addition to their non-liability to shrink, rot, or decay, these fireproof blocks afford a reliable fixing with a minimum amount of labor, and at the same time answer as ordinary bricks. By turning straight arches over ordinary inside openings, and inserting in same a couple of these fireproof blocks as a fixing for head linings, the wood lintels may be entirely omitted. In floors of fireproof construction (whether brick or concrete be employed), these fireproof blocks can be so

arranged as to offer a good fixing for the floorboards above and for the laths below, without using any wood or other inflammable material whatever.

The blocks may be beneficially introduced wherever it is necessary to nail or screw anything to brick, stone, or concrete walls, either in carpenter's, bellhanger's, or gasfitter's work, and they can be readily snapped or cut with a trowel.—*Build. News.*

REVOLVING CALCINING FURNACES.

FURNACES in the form of revolving cylinders are widely known and considerably used in this country, notably in the case of "black ash" furnaces in alkali works; also as revolving puddling furnaces and the Siemens revolving "direct process" furnaces for producing iron. As calciners, revolving cylinders have not found much use, the branches of metallurgy to which they are particularly adapted not being much practiced here; though in the form of the Oxland and Hocking furnace they have been recommended and employed for the calcination of arsenical pyrites for the production of arsenious acid. In America revolving cylinders are largely used in the working of silver ores, being found very effective for calcining or roasting the ore with salt, for the purpose of chloridizing the silver preparatory to its extraction by various process in use. There are three well-known forms of furnace in operation—the Howell, the White, and the Bruckner. The two former are "continuous action" furnaces, the ore being fed in at one end and passing out at the other, the cylinder being set at an inclination for this purpose. They are long furnaces, and comparatively narrow. The Bruckner furnace is shorter and wider, and is not continuous in its action, each charge being kept in the furnace as long as desired, and then emptied out completely. The furnace is set without any inclination of the cylinder. It is much in favor as a chloridizer, and has the advantage of being more suitable than the other forms of cylinder for use in oxidizing-roasting of sulphides when required. Revolving calcining cylinders have not so far had any great success, or obtained favor, in the treatment of lead ores as a preliminary to cupola smelting. Smith's furnace, which has been used in America, was a long cylinder, set at an inclination, with the ore feed at one end, the other end being connected directly to the hearth of a reverberatory furnace, in which the ore was agglomerated after coming from the cylinder, the calcination in the cylinder being carried on by the waste heat passing off from the reverberatory furnace. A furnace of this description would not be suitable for treating many lead ores, which would get pasty and semi-fused at the hotter part of the cylinder, and cause much trouble and imperfect work. But the cylinder furnace has recently been taken up and adapted to lead smelting in a very ingenious manner by Mr. T. C. Huntington, manager of the large works of Messrs. G. Henfrey and Co., near Spezia, in Italy. These works are almost the largest of their kind in Europe, and are most excellently equipped in all respects for working lead-silver ores. The method of smelting is mainly that of calcination and agglomeration, followed by reduction in blast furnaces. Mr. Huntington, though finding advantages in the use of the revolving cylinder, found it better to have cylinder and agglomerating furnace quite separate. It was also found that with the cylinder fired at one end, as usual, satisfactory results were not obtained, as with many ores the temperature necessary to carry on active oxidation at the flue end was sufficient to clot and sinter the ore at the fire end, preventing further efficient calcination, and clogging the cylinder. After some experiments, the arrangement finally adopted by Mr. Huntington is as follows: The cylinders, some 15 ft. long by a little under 5 ft. wide, revolving in the ordinary manner on rollers, are placed horizontally, and are fired by producer gas. At each end is an inlet for gas and for hot air, it being so arranged by means of reversing valves that the direction of the flame may be changed as desired, as in the ordinary regenerative furnaces. The charge of ore is fed into the cylinder, from a hopper placed over it, and its calcination is watched through openings left for the purpose in the ends. When it was found that the ore is so hot at the fire end of the cylinder that sintering might commence, the gas and air are reversed, and so the greatest heat removed to the cooler end, till that in turn becomes hot enough to require reversing to take place. In this manner it has been found possible to carry on the oxidation of lead ore, rich in silica, and particularly liable to clotting, without any difficulty, and to a degree of perfection not obtained in any of the ordinary forms of calcining furnaces. When a charge is finished, it is discharged through doors in the sides of the cylinder, as is done in the Bruckner furnace, into a hopper wagon placed below, the wagon being then raised by hydraulic lift to the top of the agglomerating furnace. This latter works continuously at a sufficiently high temperature to at once liquefy the ore, which comes to it thoroughly oxidized from the cylinders. Sulphate of lead, formed during calcination, is decomposed by the well known action of the silica, the final product obtained being a slag almost completely free from sulphur, and in excellent condition for the following treatment in the blast furnace. The cylinders and agglomerating furnaces are placed close together, the waste heat from the latter being utilized in heating the air for the cylinders, by means of a "recuperator," built in a chamber at the flue end of the furnace, the air on its way to the cylinders passing through pipes or channels in brickwork, which are heated from outside by the furnace gases passing away to the main flue, as in the recuperator of the Ponsard furnace. This supply of hot air to the cylinders very much diminishes the quantity of gas required for heating them, and materially assists calcination.—*Engineering.*

ON THE EFFECT OF MOISTURE IN MODIFYING THE REFRACTION OF PLANE POLARIZED LIGHT BY GLASS.—The following note was lately read before the Physical Society by Mr. R. T. Glazebrook. The author described some experiments he had been engaged in lately at the Cavendish Laboratory. Plane polarized light is made to fall on a plate or a wedge of glass at various angles, and the position of the plane of polarization determined. It is found that this depends greatly on the hygrometric condition of the air in the neighborhood of the glass. If moist air be blown on to perfectly clean glass, the plane of the polarization of the emergent light is displaced from its normal position in one direction, while if dry air be blown it is displaced in the opposite direction. At an angle of incidence of 60° the difference between the two positions is from 6' to 8'. If, however, the glass be not perfectly clean the effect of moisture is *at first* the same as that of dry air, though on stopping the draught an opposite effect is observed. The author assigns as the cause of this the heating of the surface which, as Magnus discovered, is produced by a draught of moist air. He finds on repeating Magnus' experiment that the heating is not produced if the glass be clean, and he shows by an independent experiment that slight local heating does produce an effect on the plane of polarization in the same direction as that due to the dry air.

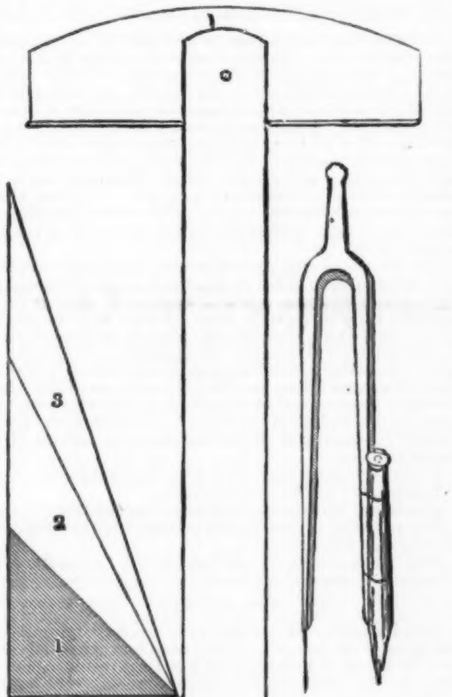
HOME MADE DRAWING TOOLS.

WE always admire a set of nice drawing tools, and have no doubt the readers of the *American Artisan* do also. For the benefit of those who do not have a set of tools, we will describe how to make them.

For the drawing board and paper what is known as a figuring block, or block of blank paper, does very well. As the paper is cut square, it combines drawing board and paper in one. The sheets are of uniform size convenient to preserve, and it is a good plan to keep all drawings made. If a figuring block cannot be had, then a square pine board will do to fasten the paper to.

The thumb tacks to fasten paper to the board can be made by soldering short needle points to the concave sides of small punched pieces of tin. The needle points can be held while soldering, by pushing them into a small stick.

The diagrams below are about one-half the size of the drawing tools I use. The blade of the T square should be about 9 or 10 inches long, or as long as the drawing board. The cross piece at the top will be about half as long as the blade. The angles are represented as lying one on top of the other. The base may be about 2 inches, the perpendicular of No. 1 also 2 inches; perpendicular of No. 2, 4 inches, and that of



No. 3, 6 inches. It will be found convenient to have two or three sizes of dividers. The above diagram may be considered full measurement for the smaller or medium size.

The T square is made of Russian iron, the blade being fastened on to hand piece with one rivet, so that it can be changed if found to be out of square. Bend the straight side of the hand piece over in the locker, one-eighth of an inch.

To make the dividers, bend up a piece of thin iron V shape and fill with solder. Take a piece of this solder bar thus made, say 6 inches long, and solder a piece about one inch long to the center of long bar (at right angles). Then solder a short piece of needle to one end of the long bar, and a tin tube on to the side of the other end, to carry a pencil. Now bend the bar in the center, and you have a pair of needle pointed dividers. Another pair can be made with a needle at each end for spacing. When they break after much bending—make another pair.

In drawing, pieces of wood of various angles are used. These can also be made of Russian iron, and as the iron is black they are easier to work with than the expensive wooden angles. If any person can get up a set of drawing tools cheaper or easier than we have described, we should be pleased to hear from them.—*R. A. Smith, Amer. Artisan.*

SOLDERING OF LEAD BY MEANS OF LEAD CHLORIDE.

THE use of the copper bit for soldering with tin or soft solder and zinc chloride as flux is accompanied by difficulties, and limited to very few metals. These difficulties become enhanced when pure lead is used as solder. Substitution of lead chloride for a solution of zinc chloride and sal ammoniac not only facilitates the process of soldering with soft solder, but also permits soldering with pure lead. This method of Wachthausen consists in the application of lead chloride in state of fusion and immersion of the heated copper bit in the flux; the solder being then applied as usual. In this manner lead, zinc, copper, brass, and iron (coated with tin, zinc, and lead) have been soldered with lead. The employment of lead chloride as flux does not necessitate a previous filing or coating of the soldering iron with tin, since a superficial cleansing from coal and ashes renders it effective. For coating of metals with a metallic layer, similar results have been obtained; the metals to be coated were either simultaneously or successively passed through the molten flux and metal, or, when necessary, the flux was fused upon the metal itself. Of the metals which have been coated with lead, we mention copper, zinc, iron, brass, and tin. The advantages derived from the use of lead chloride refer to the economy in material and saving of time and labor. As substitute for solder, lead is preferable to tin and soft solder, being cheaper and less subject to the action of chemical agents. Lead chloride being applicable to soldering of lead with lead by means of a soldering iron, which hitherto could only be accomplished with an expensive apparatus, and also superseding the filing and preparatory tinning of the copper bit, will be found a valuable adjunct and substitute for zinc chloride, etc. The formation of a metallic layer of zinc or tin upon iron demands a very superficial cleansing of the iron, while in tinning of copper or brass a preparatory cleansing of the metal can be omitted.

THE MILLING OF ORES.—STAMPS VERSUS ROLLS.

MR. C. A. STETEFELDT has contributed to Mr. Horatio Burchard's last volume on the statistics of the production of the precious metals, a paper reviewing recent progress in the milling of silver ores. We quote from it the following part, which relates chiefly to the question now so widely discussed as to the comparative merits of stamps and rolls for crushing. Mr. Stetefeldt, we presume, speaks specifically of Krom's design of rolls, because figures on their work were available to him, although, of course, rolls are built for practically the same purpose by other manufacturers.

The stamp battery still remains the most troublesome part of the mill plant. It is true the battery of to-day is far superior to that of twenty years ago, not only in efficiency and durability, but in auxiliary appointments. The dusty chamber in front of the battery, where the pulp accumulated, and which had to be entered by a laborer to load a car, has given way to elegant conveyers and elevators, which remove the pulp continuously and take it to the roasting-furnaces. Dust-chambers now connect with the battery-housing, into which the dust, formerly escaping from every opening and settling upon machinery, is drawn by a suction fan, to be regained, and finally mixed with the pulp before it enters the roasting-furnaces. Machinery has also been perfected for the separate crushing and feeding of the salt, this being of advantage in some respects.

The first decisive departure in pulverizing ores dry was made by the introduction of Krom's rolls at the Bertrand Mill, Nevada, in 1882. While rolls had been generally used for pulverizing ores for the purpose of concentration, it remained for Mr. Krom to construct rolls suitable for producing pulp for subsequent treatment by roasting and amalgamation or lixiviation. By providing the rolls with steel tires, running them at the high speed of 100 revolutions per minute, with pulleys only, and constructing them in a most substantial manner generally, he succeeded where others had failed. Leaving, for the moment, the purely economical question out of view, I will consider the physical difference that exists between pulp produced by each of the two machines. If pulp produced by rolls, or by stamps, is sifted through the same size of screen, the ore particles from the former are more uniform in size than those from the latter. The pulp from the rolls contains much less of such fine material as will pass, say, through a No. 100 wire screen, down to the impalpable dust. Based upon experience in raw amalgamation, it was formerly assumed that the production of an impalpable powder was essential to success, even in case the ore had to be roasted before amalgamation. Hence it was the general practice to crush through a No. 80 or No. 60 screen in the older mills of Nevada. While this practice was gradually abandoned, and crushing through No. 40, and finally No. 30, screen was in most mills adopted, the subject was never fully investigated until recently. It has been found that for chloridizing-roasting great fineness of the ore is entirely unnecessary, and that it is actually injurious in the amalgamation of roasted silver ores. Of course, the character of the ore has always to be taken into consideration. In the lixiviation process, a large percentage of fine material interferes seriously with rapid filtration, and unnecessarily lengthens the time of working a charge. From this, it follows that ore pulverized by rolls is mechanically in a more favorable condition than if stamps have been used.

I turn now to the question of economy. A discussion of the subject that is complete and thorough, and compares the efficiency of rolls and stamps under varying conditions, is not possible at present, because the available statistics concerning rolls are confined to those from the Bertrand Mill, Nevada. Prior to the introduction of Krom's rolls in this mill, they were used in works only erected for the concentration of ores by Krom's dry system. Sufficient evidence, however, has accumulated to prove the superiority of the rolls beyond any doubt. Their introduction at the Mount Cory Mill, Nevada, will soon bring additional proof. It seems to me that the application of rolls is most favorable in such cases in which the silver is extracted by lixiviation, and the character of the ore permits comparatively coarse crushing without interfering with good roasting.

A comparison between rolls and stamps will be made from the following premises, for the correctness of which I must ask the indulgence of the reader. I assume that the crushing capacity of two sets of Krom's 26-inch rolls is equal to that of a 30-stamp battery with stamps of 850 pounds dropping from 7 inches to 8 inches 94 times a minute. Mr Clark, superintendent of the Bertrand Mill, states that he can crush, with two sets of rolls, 100 tons of ore in twenty-four hours, to such a fineness that all will pass through a No. 16 screen, consuming not over 4 cords of wood for power. The ore has a quartz gangue, and is by no means an easy crushing ore. The fuel required for running 30 stamps would

be about 6 cords of wood in twenty-four hours, taking into consideration the construction of engine and boilers and quality of wood. For some remote locality in the West, the following prices are assumed, namely: Freight at 3 cents per pound; lumber at $50 per thousand feet; wood at $6 per cord; wages of carpenters at $4.50 per diem, and of millwrights at $6. Certain items of construction will be about equal, namely: Conveyers, elevators, revolving screens, and dust-chambers. Revolving screens are also used in connection with a well appointed battery, in order to separate coarse material resulting from a breakage of battery screens. The building, however, for rolls will be much smaller than that for the battery, and a saving of not less than $1,500 will be effected in its construction. Finally, the rolls requiring less power, a saving of at least $1,250 will be made in providing and setting up engine and boiler in a mill with rolls.

Cost of erecting a 30-Stamp Battery.—The plant, including hard-wood screen frames and guides, wooden pulleys on cam-shafts, Tulloch's feeders, and all necessary bolts, weighs 90,600 pounds, and costs in Chicago $5,850, according to a statement from Messrs. Fraser & Chalmers. The framework takes about 36,000 feet of lumber, and the expense of setting up the battery is estimated at $4,000. Hence the total cost of constructing a 30-stamp battery is:

Plant at foundry	$5,850
Freight	2,718
Lumber	1,800
Cost of setting up	4,000
Total	$14,368

To this has to be added, in order to compare with rolls:

Extra cost of building	$1,500
Extra cost of engine and boilers	1,250
Total	$17,118

Cost of Erecting Two Sets of Krom's 26-inch Rolls.—The amount of lumber required for setting up the rolls alone is merely nominal. From this it follows also that the labor of placing the rolls must be trifling. The weight of one set of 26-inch rolls is 12,000 pounds, and the cost in New York, 2,250. There is one self-feeder required and its weight is estimated at $2,000 pounds; cost, at $200. From these figures I deduce the following:

Plant at foundry	$4,700
Freight	780
Cost of setting up	700
Total	$6,180

Difference in favor of rolls, $10,938.

Wear and Tear of Stamps and Rolls.—In comparing the wear and tear of stamps and rolls, we cannot very well express this item per ton of ore crushed, because the capacity of the pulverizing machinery is a function of the hardness of the ore and of the fineness of the pulp produced. A more correct method will be to take figures per running time of twenty-four hours. Making estimates from this standpoint, it is supposed that the wear and tear in running the machinery at full capacity is a nearly constant quantity, while the capacity is variable, as stated above. The wear of rolls is principally confined to the steel tires; that of the battery, to a great number of parts. With rolls, the steel tires can be consumed to within less than one-half inch of their thickness, while with stamps the shoes and dies have to be exchanged after only two-thirds, or less, of their weight has been worn, leaving other parts out of consideration. Another point should not be overlooked. The complicated construction of the battery causes considerable expense in skilled labor for repairs, which, in the case of rolls, is merely nominal. Advocates of the battery have argued that its great advantage is the continuance of its operation if one battery of five stamps gets out of order, while both sets of rolls, or three sets, as the case may be, have to be stopped if repairs are needed for one set. But it is just the solid construction of Krom's rolls that reduces stoppages from this cause to a minimum. How often it is necessary to hang up stamps for repairs is too well known to require any statistical proof.

Wear and Tear of Krom's Rolls.—As to statistics of wear and tear of Krom's rolls, I am confined at present to those from the Bertrand Mill. Mr. R. D. Clark states that two sets of steel tires have been worn out in crushing, in round figures, 20,000 tons of ore. As stated previously, the full capacity of the rolls is in twenty-four hours 100 tons, the ore being sifted through a No. 16 screen. In the beginning, however, the ore was crushed much finer, namely, so as to pass a No. 20 screen, and the daily capacity of the rolls was much less. Taking this into consideration, the actual wearing capacity of the tires cannot be estimated at less than 250 working days. The cost of this wear is as follows: Two sets of steel tires cost at New York $764, their weight being 3,264 pounds. With freight at three cents, the total cost of these steel tires is $862.

Wear and tear of steel tires in twenty-four hours	$3.45
Wear of other parts, screens, lubricants, and supplies	1.75
Wages for repairs	1.25
Total	$6.45

Wear and Tear of Stamps.—I have been favored with statistics from three of the most prominent mills in the West, namely, the Manhattan, Nevada; the Ontario, Utah; and the Lexington, Montana. Taking into consideration the somewhat abnormal conditions of the Manhattan Mill, in so far as the weight of stamps there is 1,000 pounds, and the number of drops per minute greater than in either of the other mills, and that the statistics from the Lexington are those from the first year's run, where certain breakages are reduced to a minimum; finally, that freight in these localities, on account of direct railroad communications, is less than I have assumed in my premises, I arrive, by making such allowances, at the following figures for wear and tear of a 30-stamp battery per twenty-four hours' running time:

Cost of all parts subjected to wear and breakage, screens, supplies, and lubricants	$11.50
Wages for repairs	5.50
Total	$17.00
Wear and tear of rolls	6.45
Difference in favor of rolls	$10.55

Interest and Amortization.—In comparing the expense of running rolls and stamps, interest and amortization on the excess of capital required in the original construction of the plant for stamps cannot be neglected. Considering the short life of most silver mines in this country, this item cannot be taken at a lower rate than 15 per cent. per annum. If we take the running time of a mill at 350 days in the year, and consider that the mill with stamps will cost $10,938 more than one with rolls, the interest and amortization amount to $4.68 per day.

Summary.—From the above we find the following daily saving in a mill with two sets of Krom's rolls, as compared with 30 stamps:

Wear and tear and repairs	$10.55
Interest and amortization	4.68
Fuel, two cords of wood at $6	12.00
Total	$27.23

If no great accuracy can be claimed for this estimate, it is the best that can be given at present, and it is sufficiently correct to prove the economy of rolls beyond any doubt. Mr. Krom and Mr. Clark claim a much greater saving in favor of rolls than that stated above. The future will demonstrate the correctness or fallacy of this view. Even if we consider two sets of rolls equal in capacity to only twenty stamps, there still remains a considerable margin in favor of rolls.

ON THE PAINLESS EXTINCTION OF LIFE IN THE LOWER ANIMALS.*

By BENJAMIN WARD RICHARDSON, M.D., F.R.S.

DURING the latter part of last and the early part of the present year, I constructed at the Dogs' Home, Battersea, at the request of the committee of that institution, a lethal chamber for the painless extinction of the life of the animals which have, of necessity, to be destroyed there. I put the process first into operation on Monday, May 15, by subjecting thirty-eight dogs to the fatal narcotic vapor. They all passed quickly into sleep, and from sleep into death. Since that time, up to the present time, a period of seven months, the lethal chamber has been regularly in use. From 200 to 250 dogs per week have been painlessly killed in it, or a total of nearly 7,000.

The results of this procedure have been so exceptionally large, and so entirely practical and successful, the time has now come when they ought, I feel, to be brought fully into public record before this Society. I say specially this Society—the Society of Arts—because it has become by age and by nature, in England, the happy hunting ground of happy inventions, a kind of literary record office, in which the scholar of the future will find some notice of almost every discovery and mechanism which has in our time been constructed for the benefit of man and of his humble companions of the lower creation.

In this lecture I shall deal with four subjects:

The history of the lethal process.

The lethal process in its present application.

The relation of the lethal process to other processes having the same object.

The extension of the lethal process to the slaughter of animals intended for food.

THE HISTORY.

The history of the lethal process, for extinguishing the lives of the lower animals, may be very briefly told. It follows, as a natural and practical result, upon the process of anæsthesia for the human subject about to undergo a surgical operation without feeling the pain of the operation. It is, in fact, such anæsthesia, but with this difference, that whereas in ordinary anæsthesia for an operation, the operator allows the subject who has been narcotized to return from his deathly sleep into the communion of life, in the case of the lower animals placed in the lethal chamber, the administration of the anæsthetic is sustained until the induced artificial sleep becomes the veritable sleep of death. In about one instance in three thousand it occurs, by accident, to man under chloroform that he dies in the same way. From the borrowed semblance of "shrunk death" he passes, usually, without a struggle, when the sad accident occurs, into actual dissolution.

The thought of applying the anæsthetic method to the painless destruction of the lives of the lower animals, and the first accomplishment of it, came from myself, and dates back as far as the year 1850.

In that year, I constructed at Mortlake, where I was then starting in practice, a small lethal chamber, to which my neighbors would frequently bring animals which they wished to have killed. In 1854, I began to illustrate this mode of painless death, and from that time up to 1871, I never allowed the subject to rest. In 1871, I brought it formally before the Medical Society of London, at the opening meeting of the 99th session, in a paper, afterward published separately, entitled "Note of a Preliminary Research to Discover a Practical Method of Killing Animals without the Infliction of Pain." In this paper I discussed other modes than the lethal, to which I will refer under the third head of the present lecture.

About this same time, I made, through Mr. Colam, a communication to the Royal Society for the Prevention of Cruelty to Animals on the same design, and suggested a mode for killing painlessly dogs and cats that were wounded in the streets, and I have to thank the committee of that society, and Mr. Colam, for the interest they took in my endeavors.

From that time downward to the present I have continued the inquiry, making use of all the known anæsthetic substances, in order to ascertain which was cheapest, most adaptable, most certain in action. The information, thus obtained, proved very useful when the time came for utilizing it. That time came last year, when Mr. Kennett was good enough to offer the sum of £200, in order to enable the lethal method to be carried out at the Dogs' Home, where, as I have already said, it is now in operation.

THE LETHAL PROCESS IN ITS PRESENT APPLICATION.—DETAILS.

In undertaking the practical act of carrying out lethal death on the large scale required at the Home, I had to determine, in the first place, on the anæsthetic or anæsthetics to be used, and, in the second place, to construct the room or chamber in which the animals should be confined while exposed to the lethal gas or vapor.

THE ANÆSTHETIC.

I have placed on the wall a table of anæsthetics, including most that have, up to this time, been discovered, with a general outline of their respective properties and values. There is, you see, a goodly list, twenty-two in all. Out of these I selected, as shown by experiment to be the best, four:

Carbonic oxide.
Chloroform.
Carbon bisulphide.
Coal gas.

Carbonic Oxide.—I was led to carbonic oxide, not only by reading of it, and by witnessing the effects of it as a poison when it has been breathed from coke fumes, but specially from studying its action when evolved from the fumes of the *lycoperdon giganteum*, or common puff-ball. The fumes, as thus evolved, have been employed for centuries past by the common people for narcotizing bees before taking the honey from the hive. A portion of the substance being burned under the hive, the bees, inhaling the fumes, fall into a deep sleep, during which time they are unconsciously deprived of their industrious earnings. I was so struck with the perfect action of these fumes after being shown one of these experiments, that, in 1854, I introduced the fumes for anæsthetic purposes. Purified by being passed through water they produced the most rapid narcotism, under which many operations were performed painlessly on the inferior animals. The question was the character and chemical nature of the agent in the fumes which produced the anæsthesia. The late Dr. John Snow, so well known for his immense labors on anæsthetics, and the late Mr. Thornton Herepath, one of our most promising chemists, were each separately engaged in discovering the concealed gas or vapor. Snow and Herepath ran ahead of me in the inquiry. They, simultaneously, but by quite different methods of research, arrived at the fact that the narcotic present was carbonic oxide, or the same gas as is produced during the combustion of carbon or coke in a limited supply of oxygen.

These researches led me to study the action of this gas in its pure form, and to the discovery of many curious facts relating to it. Among other things, I noticed that, like oxygen, it made the venous blood of a bright red color, and that warm-blooded animals exposed to it for a long period of narcotism are rendered temporarily diabetic.

I did not, on the whole, think it commendably safe as an anæsthetic for man, but I fixed upon it at once as one of the best and cheapest of lethal agents for the painless destruction of life in the lower creation. It is the principal agent for this purpose which I have used since the date named above, 1854.

Carbonic oxide is a gas, and if quite pure is so odorless and produces so little irritation that, when present in the air, it is apt to be breathed unconsciously until the effects of it are felt. Those who by accident have been narcotized by it, and have recovered from the effects, have expressed that they had no recollection of anything whatever, that they passed into sleep in the ordinary way of sleeping, and knew no more.

The gas can be made in two easy ways. (1.) It can be made simply by passing air or oxygen over burning coke or charcoal. If air be used, the product consists of carbonic oxide, with some carbonic acid, and with the nitrogen of the air, which passes through the furnace unchanged. As the nitrogen forms four-fifths of the air, the product is, of course, very much diluted. A hundred cubic feet of an atmosphere so produced does not contain more than 15 per cent. of the gas. Such an atmosphere is, nevertheless, very deadly, because the nitrogen, entirely negative, has no power of sustaining life. When oxygen is used alone in limited quantity, the gas is turned out practically pure. By either mode—by common air or oxygen—one pound of charcoal should yield 31 cubic feet of the lethal gas, assuming that the combustion is correctly carried out.

(2.) The second mode of making the gas is by passing carbonic anhydride, still commonly called carbonic acid, over red hot charcoal. The charcoal in this instance is placed in a tube, into which the carbonic acid, CO_2, can flow. The tube is put into a furnace, the charcoal is made red hot, and while in this state the carbonic acid passes over it. The carbonic acid is thus deprived of one part of its oxygen by combination of oxygen with the heated carbon, and carbonic oxide escapes at the exit of the tube. The gas thus formed is practically pure, and is very deadly. If even a little carbonic acid does pass over in its free state, the lethal action is sustained, carbonic acid being itself a gas destructive to life.

Chloroform.—I was naturally led to chloroform, by reason of its common use as an anæsthetic. There is no anæsthetic more certain in its action, and none more certain to kill if it be administered in a determinate manner. Administered even with skill, so as not to kill, it proves accidentally fatal about once in 2,500 times, and so soon as air is charged with over 5 per cent. of its vapor, it is not breathed without danger. Death from it is very determinate when it occurs, and seems to be entirely painless.

The vapor of chloroform does not burn. On the contrary, it extinguishes flame. If we plunge a lighted taper into a jar through which the vapor of chloroform has been diffused, the light is at once extinguished. I shall show, in the sequel, that this has a certain useful bearing on the subject now before us, apart from the matter of fatal narcotism.

Chloroform, being purchasable as a chemical fluid, I need not refer to its manufacture. When we use it for narcotism, we merely diffuse the fluid into the state of vapor, and make provision for the vapor to be ab-

* A Lecture before the Society of Arts, London, Dec. 18, 1884.

TABLE OF ANÆSTHETIC GASES AND VAPOURS.

NAME OF SUBSTANCE.	Elementary Composition.	Material Condition.	Gas or Vapour density H = 1·	Fluid Density water = 1·	Boiling point.		PHYSICAL QUALITIES.
					Cent.	Fahr.	
					Deg.	Deg.	
Nitrous oxide	NO	Gas	22	...	...	...	Supports common combustion: sweet, and not irritating to breathe.
Carbonic oxide	CO	Gas	14	...	...	...	Burns in oxygen; not irritating to breathe.
Carbonic acid...	CO_2	Gas	22	...	...	...	Extinguishes flame; irritating to breathe.
Bisulphide of carbon	CS_2	Fluid	38	1·270	43	107	Vapour burns; odour disagreeable unless well purified.
Hydride of methyl (marsh gas)...	$CH^3 H$	Gas	8	...	...	...	Burns air; inodorous, not irritating.
Methylic ether	$C^2 H^6 O$	Gas	23	...	...	...	Burns in air; almost inodorous when pure.
Methylic ethyl ether	$C^3 H^8 O$	Fluid	30	...	11	52	Burns in air; ethereal odour; rather pungent.
Chloride of methyl	$CH^3 Cl$	Gas	25·25	...	...	...	Burns in air; rather pungent.
Bichloride of methyline	$CH^2 Cl^2$	Fluid	42·5	1·320	40	104	Vapour burns; pungent odour.
Chloroform	$CH Cl^3$	Fluid	59·75	1·480	61	142	Vapour extinguishes flame; pungent odour.
Tetrachloride of carbon	$C Cl^4$	Fluid	77	1·560	78	172	Vapour extinguishes flame; odour fragrant, not pungent.
Hydride of ethyl	$C^2 H^6 H$	Gas	15	...	...	...	Burns in air; inodorous.
Ethylic ether (absolute ether) ...	$C^4 H^{10} O$	Fluid	37	·720	34	93	Burns in air: pungent to breathe.
Chloride of ethyl	$C^2 H^5 Cl$	Fluid	32·25	·921	12	52	Burns in air; ethereal odour; rather pungent.
Ethylene (olefiant gas)	$C^2 H^4$	Gas	14	...	...	...	Burns in air; pleasant to breathe.
Bichloride of ethylene (Dutch liquid)	$C^2 H^4 Cl^2$	Fluid	49·5	1·247	80	176	Vapour burns; ethereal odour; rather pungent; smoky.
Chlor-ethylidene	$C^2 H^4 Cl^2$	Fluid	49·5	1·174	64	147	Vapour burns; ethereal sweet odour; pungent.
Bromide of ethyl (hydrobomic ether	$C^2 H^5 B^r$	Fluid	54	1·400	40	104	Vapour rather pungent, but pleasant.
Hydride of amyl	$C^5 H^{11} H$	Fluid	36	·025	30	86	Vapour burns in air, inodorous when pure.
Amylene	$C^5 H^{10}$	Fluid	35	...	39	102	Vapour burns in air; pungent; smoky.
Hydrocyanic acid...	HCN	Fluid	...	·705	26	79	Vapour painful to breathe; special; suffocating odour.
Coal gas	...	...	...	...	...	...	Gas at first slightly irritating, but quickly narcotic.

sorbed by the lungs of these subjected to it. It produces little irritation when breathed.

Bisulphide of Carbon.—The bisulphide of carbon is a very rapidly-acting anæsthetic. It produces narcotism, in fact, almost as quickly as carbonic oxide, and with less muscular commotion. The vapor of it burns in air if a light be brought near to it, but when its vapor is mixed with that of chloroform, this danger is avoided. It is bought, as chloroform is, in the fluid state, and can be obtained, therefore, from the chemist directly, ready for use, by diffusion of its vapor. It has one immense advantage, that of being excessively cheap; and it has one great disadvantage, that of being excessively unpleasant in regard to its odor, unless it be most carefully purified by repeated distillations. Combined with chloroform, with which it mixes freely, the peculiar odor is largely reduced, and by pouring the mixture over chloride of lime, is almost entirely removed. For this reason, together with that relating to the difficulty of combustion of the combined vapors, I have used largely in these researches the mixture of chloroform and carbon bisulphide. The combined vapors produce also a singularly good antiseptic atmosphere. Specimens of the chloroform-bisulphide compound are on the table.

Coal Gas.—Common coal gas is one of the most potent of narcotizing gases. I pointed this fact out in the very early days of anæsthesia. The gas is a compound of four gases, three of which are excellent narcotics, and one a negative gas. It contains 47 per cent. of hydrogen, 42 of marsh gas, 3 of heavy hydrocarbons, and 8 of carbonic oxide. All these gases are anæsthetic in their action; marsh gas is one of the best, and carbonic oxide is one of the quickest; but they are all explosive.

For the lethal purpose, nothing could possibly surpass coal gas. I put it freely to the test, and found it was all that we could desire. In an atmosphere containing 25 per cent. of this gas, an animal goes to sleep in from two to three minutes, and dies asleep as easily as in any narcotic vapor or gas whatever. The gas is always at hand, and for the present purpose is the cheapest and readiest of all. Used in the lethal chamber at Battersea, 100 dogs could be put painlessly to death at the cost of a shilling, and without any more trouble than that of turning on and off the gas.

Under such circumstances, it seems absurd to think of going any further for a narcotic agent. And yet it is necessary, at all events, when a large lethal chamber is wanted, on account of the danger from explosion. I feel so sure that an accident by explosion would occur from the frequent use of the gas in this manner, that I dare not undertake the responsibility of recommending it, except on a smaller scale, which has yet to be considered. A man smoking his pipe near the chamber, or carrying a light, or striking a match, might lead to the accident, or the spark from the friction of the wheels of the cage carrying the animals with the tram beneath them, and on which they rub, might cause the accident.

I hoped at one time that I had overcome this risk by the very simple expedient of letting the gas pass into a chamber through chloroform. The vapor of chloroform mixing with the gas would, I believe, prevent explosion, even if a flame were introduced. I therefore combined the gas with the chloroform, and found in the combination not only a splendid narcotic, but apparently a safe one in regard to explosion. I was disappointed. I narcotized an animal to death in a mixed atmosphere of coal gas and chloroform, and that both easily and safely. The chamber containing the animal was left for three hours, and at the close of that time the gas in it was not explosive, the vapor of the chloroform controlling the combustion. But the following morning, on striking a light in the chamber, the gas took fire with considerable force. During the coldness of the night, the vapor of chloroform had condensed, and left the gas free.

After this experience, I gave up the idea of using coal gas on a large scale. I think it may be useful in a small apparatus under some circumstances, but I would not, while admitting its many advantages, dare to recommend it as of general application.

All things considered, I was led to conclude that carbonic oxide was the best narcotic agent to employ, combining it with chloroform or carbon bisulphide if that should prove necessary. Deciding on this point, the next question was how to manufacture the carbonic oxide so as to bring it into practical use on the easiest as well as the largest scale.

I designed originally for the trial at Battersea to erect two large reservoirs, to set up an apparatus for the generation of carbonic acid, and a furnace by which this gas could be transformed into carbonic oxide. By making the carbonic oxide in this way, and charging the gas-holders with it, it would be at hand at all times to be passed into the lethal chamber.

There were difficulties in the way of carrying out this design. The first of these were the expense and the skill required to work the apparatus. The reservoirs alone would have cost a hundred pounds, and when fixed would have taken up a great deal of room; a skilled man would at the same time always be wanted to charge them and keep them in proper order.

These difficulties led me to keep to the original plan of a simply constructed stove, in which the gas should be made by burning charcoal. Here, however, when I got into experiment, I found several new difficulties which had to be removed.

The burning of charcoal in an ordinary stove produced sufficient of the gas, but the heat of the gas was such as to demand a means of cooling it before it should enter the chamber. There was also produced in the combustion so much vapor of water, that the experimental small chamber with which I first manipulated was charged with steam, which, condensing, left the walls of the chamber loaded with water, a condition most unfavorable to narcotic action, and destructive to the walls of the chamber itself.

While studying the best means of overcoming these objections, and after failing to overcome them by several methods, I luckily recalled Mr. Clark's condensing-stove. This stove, with which I have no doubt most of you are conversant, is a most ingenious invention. The fumes proceeding from the combustion in the furnace, first ascend and then descend through two lateral columns, to escape by a tube directed over a trough or saucer. A large quantity of water vapor is in this way condensed, and is collected at the base of the stove, together with substances derived from the combustion, which are soluble in water. Here, with a little modification, was what I wanted. To adapt the stove to my purpose, I got Mr. Clark to make a charcoal furnace over a gas-burner, so that, when the charcoal was laid in the furnace, it could be instantly set alight by merely turning on and lighting the gas, letting the flames of gas play through the charcoal. Next I got him to make a large condensing cistern beneath the stove, with an opening from it to convey the carbonic oxide by a tube into the lethal chamber, and with a tap, by which the condensed fluid could be drawn off. The arrangement answered straight away, if I may so say. The immediate combustion of the charcoal by the gas yielded very nearly the theoretical value of the product, carbonic oxide. The gas was deprived of water by the condensation; it was delivered over to the chamber with a steadiness sufficient for all practical necessities; it was cooled without any other artificial means, so as never to raise the chamber above summer heat; it was produced cheaply; and it afforded such simple action, that any workman could at once learn to use it. It is just to say that the immediate success which has followed my efforts has been much expedited by the use of the Clark condensing-stove.

Another useful result springing from the employment of this stove was, that it enabled me to diffuse other narcotics into the chamber, by merely allowing the warm gas proceeding from the stove to pass over a porous surface, charged with the narcotics, on its way into the chamber. So much for the narcotic to be used, and the production of it. I have now to pass to the method of applying it.

THE LETHAL CHAMBER.

To apply the narcotic gas or vapor, it is necessary to have a closed place in which the animals are exposed to the narcotic, and another place in which they are collected preparatory to being subjected to the narcotism. This implies what I have called the lethal chamber, and a cage.

At Battersea, it was necessary to have an apparatus large enough to narcotize as many as one hundred dogs at a time. It was, therefore, essential to have a large lethal chamber, and one that was strong and effectively constructed. I noted down at the beginning the following requirements, all of which I had calculated out of a series of preliminary studies, and constructed on a small working scale.

1. The chamber, of whatever substance built, must be so constructed that its interior shall not be subject to great variations of temperature. This I knew to be very important, since in observing the action of narcotic vapors on the human subject, I had learned that humidity and cold materially interfere with their quick action, while dryness and warmth favor such action. In a lethal receptacle, such as was being constructed, there could be no certainty whatever, unless the temperature and dryness were at all times uniform.

2. It was necessary so to construct the chamber that sufficient but not an excess of room should be allowed in it for the expansion of the gases introduced. It might seem at first sight, and before inquiry was instituted, that the more the space within the chamber was reduced, the quicker would be the effect. This, however, is not practically the fact. In order to secure perfect diffusion of the narcotic atmosphere, the space to be filled with it must be about one-eighth greater than is absolutely required for a cage fully charged with the animals that have to be killed.

3. Much care is required in connecting the stove with the chamber, so as to make sure of equal diffusion of the gases or vapors through the inclosed space. Unless this equal diffusion is rendered effective, some of the animals are more exposed to the vapors than others, and the effects are irregular, which is as bad a result as could possibly be obtained.

4. It was essential to provide that a sufficient quantity of the narcotic should be introduced before and for a brief period after the introduction of the animals.

5. It was requisite to invent a plan by which the chamber could be kept completely closed until the precise moment when the animals have to be introduced, then instantly opened for the introduction, and as instantly closed after the introduction. It was equally requisite to guard the entrance into the chamber, so that the men employed in pushing in the cage should be protected from the vapor. A method had also to be adopted by which it could be known when all the animals had ceased to breathe.

To meet the first of the above-named conditions, I constructed the lethal chamber (the outline of which is shown in Fig. 1) of well seasoned timber, making every part of it a double wall, and filling the interspace closely with sawdust. The plan has answered all my expectations, and, with wood as the material for construction, I doubt if it can be improved upon. Should iron ever be used, and I can imagine that it is sure to be, it will be essential to have a double wall, and to fill up the interspace with a layer of Croggon's felt, an inch in thickness, or with the slag felt which was brought before the notice of this Society when I was delivering the Cantor course on the preservation of animal substances. Every part of the construction ought to be, in this manner, double lined. Should the chamber be built in brick, the wall should be of 9-inch thickness, and of glazed brick in the interior. I am of opinion that a well-built brick chamber would answer excellently well. The roof of such a place should either be an arch of brick, or iron, or wood, closely covered with felt. An inner lining of wood covered with felt, and overlaid with galvanized iron, would be very effective.

In order to obtain the slight excess of space which was wanted to insure diffusion, I formed on each side

of the chamber an extra space, which I call a pocket. The spaces, one on each side, were at first too large, and I had to reduce them, from the inside, to the size I have already indicated as the best. They are in the center on each side, and stand out as aisles from a central nave.

In order to secure quick and equal distribution of the vapors through the chamber from the stove, I let the gases in at first from the top, under the impression that the gases, being heavier than the atmosphere, would be made to pass with greater rapidity into all parts. Theoretically, this view is correct; but as it became necessary to have two floors or tiers to the cage, I was obliged, in the end, to let in the gas half way down the sides of the chamber. By using two stoves, one on each side, this method of introduction was both convenient and effective; I do not think it could be better, however altered. To remove the common air, an opening, with a shaft of ten feet, was made in the roof. The shaft has a bore

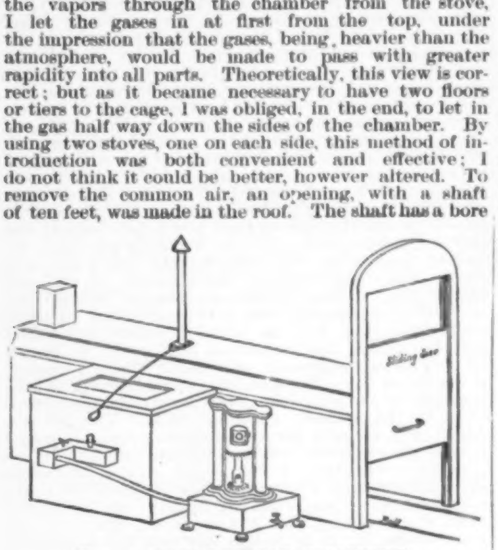


FIG. 1.—THE LETHAL CHAMBER.

of three inches, and has a cap at the top, in order to prevent down currents of air. At the foot of the shaft is a damper, which can be opened and closed at pleasure. The directions to the managers are, to open the damper when the stove is first lighted, and let it remain open for half an hour; then to close it partly for another half hour, and after that to close it entirely, and not to reopen it until the chamber is again required.

To meet the fourth necessity, a plentiful supply of the narcotizing vapor, two stoves have been connected with the chamber, each capable of burning two pounds of charcoal per hour, and giving up the products of the combustion into the chamber. At first—guided by the general, but not quite correct, impression as to the extremely poisonous qualities of carbonic oxide—I was content with one stove, but found it not quite sufficient, for although it delivered fifty cubic feet of the gas per hour, it acted too tardily to suit my wishes. I therefore added a second stove, which was abundantly sufficient.

To make the narcotic effect still more certain, and to keep the chamber at all times lethal, I made an extra provision. At the two points where the tubes from the stoves enter the chamber, I have interposed two strong boxes made of elm, and covered with thin lead. These boxes, which are 18 inches long, and 4 inches broad, are filled loosely with the porous burnt loam, known as Verity's patent gas fuel, an excellent substance for filling a grate where coal gas is burned instead of fuel. This substance is so porous, it takes up narcotic fluids most readily, holds them in its pores, and gives them up in volumes of vapors when warm gas is passed over it. Into the boxes, closed in with this fuel there is a funnel, opening at the top, for supplying the fluid, which can be shut with a stopper; and at the end of the box, standing out at a right angle from it, is a continuous section, in which there is a large tap for regulating the currents of gas from the stove.

When the stoves are in action, the tap is turned on, and the gases from the stove pass through the boxes over the patent fuel into the chamber. Nothing more is done until just before the time when the animals in the cage are to be introduced. Then ten fluid ounces of an anæsthetic mixture, consisting of equal parts of methylated chloroform and carbon bisulphide, are poured upon the fuel through the openings in the top of the little boxes, the openings being immediately closed. After the animals are in the chamber, ten ounces more of the same mixture are added, and if, after three or four minutes, any of the narcotized animals are still breathing, ten or twenty fluid ounces more are poured in. This is not often necessary, but, for reasons which will be explained, it is occasionally.

In pushing the charged cage into the chamber, there is naturally a very great displacement of gas and vapor within. The cage has a cubic dimension of 160 cubic feet, and the chamber with the side spaces is 200 cubic feet. To put in the charged cage was, therefore, equivalent to displacing more than half the narcotic gas or vapor which it contained. As a consequence, it was necessary to provide an exit which would save strain on the walls of the chamber, and would let out a little gas without letting in common air. The task was one which called for considerable patience and trial of method. I met it at last by the plan shown in Fig. 2,

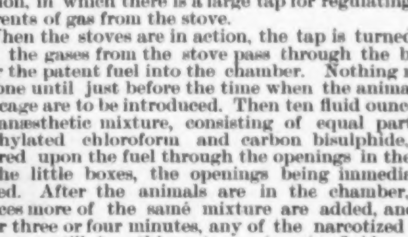


FIG. 2.—REDUCED SECTION OF FIG. 1.

which exhibits the chamber in sections. Two feet from the far end of the chamber, there is suspended from the top a light hanging screen, which reaches within four inches of the floor. Behind this screen, and in the foot of the chamber, is a shaft, with a valve opening upward. As the cage is pushed in, this screen is raised from the bottom, and the air rushing out at the lower part, ascends behind, and escapes by the valve. The screen is so balanced, that when sufficient air has been extruded, its lower end reaches the back or lower end wall of the chamber. The screen itself thus acts as a regulating valve, and when the pressure is off, it returns to its level, letting any gas at the rear of it return toward the cage.

To enable the operators to introduce the cage quickly and at the same time protect them from action of the vapors, the following plan, also indicated in the section diagram, is adopted. The door or entrance into the lethal chamber is a slide like the sash of a window. It is placed between two strong uprights, and is balanced by a weight and pulley in each, so that it can be opened and closed with the greatest rapidity. Behind this sliding door there is placed what I call the shield or block. The shield is a framework of wood with four large metal valves, two opening inward, two outward. The shield is fixed on a base with four little wheels, and run easily up or down the chamber. When the sliding door is raised, the movable valved shield is in position half a foot within the chamber, and cuts off all escape of vapor. The workmen

FIG. 3.

thus have time to push the cage leisurely, after the door is raised, into the chamber until the end of the cage touches the screen. This effected, they push the cage in a few seconds into the lethal atmosphere, the shield running before it, and then the door is slided down into its place. When all is nicely adapted, a very few seconds are required to introduce the cage and close the sliding or entrance door. When the cage is drawn out the screen is drawn out with it, by means of a cord which is attached to it, and which runs under the cage.

The last requirement which had to be met was the means of knowing when the narcotized animals had ceased to breathe. To get at this fact, the test of hearing was found to be the best. There is inserted into the chamber on one side a long stethoscope, made of bamboo; the mouth of this tube—of trumpet shape—is in the center of the chamber, just above the cage, when that is in place. The outer part or ear piece, of the tube stands out four inches on the outside, and is closed when not being used by a solid plug. On listening through this tube, the continued breathing of even a single animal can be detected, and the operators are enabled to determine if it be proper to increase the strength of the narcotic atmosphere, or to stop it.

I have now given all the necessary details of the chamber, and have only to add that it acts so well, I do not think I could improve upon it in principle if I were to construct a new one. The gases act rather on the metal pipes leading from the stoves, giving rise to some little leakage when the pressure is full on, and rendering it requisite to replace the tubes from time to time. But these are minor details which are a part of all working mechanics, and which call for nothing more than moderate attention and intelligence on the part of the men in charge, who are very soon conversant with all that has to be carried out, and with any defects that may arise.

THE CAGE.

In Fig. 4 there will be seen best a description of the cage in which the animals are collected before being put into the lethal chamber. The cage is made of a wooden frame-work, with light iron side bars. It has two sliding doors at the sides, two at one end, and one

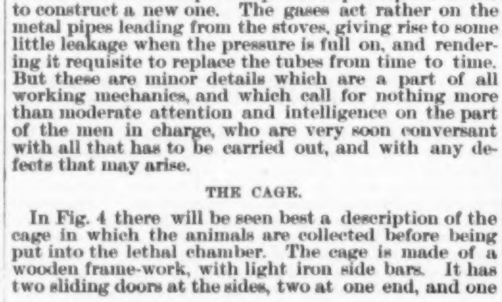


FIG. 4.—THE CAGE.

at the top. It can be filled and emptied through these doors with great rapidity. In order to hold as many animals as possible without discomfort to them the cage is divided into two divisions of tiers, the flooring of the upper tier being freely perforated with openings, so as to establish a communication between the upper and lower divisions, and allow a due distribution of the gases and vapors used. The cage runs on four 8-inch wheels, which are underneath it, and ply on galvanized iron rails. At the Home there are two cages, in order that one operation of painless killing may follow at once on another if that be necessary.

THE LETHAL PROCESS.

Having now given the details of the mechanism employed, I may describe with advantage the nature of the lethal process. The mode of death to which the animals are subject is that by anæsthesia, not by suffocation or asphyxia. Physiologically, there is a distinctive difference between these modes of death. Death by anæsthesia is death by sleep; death by asphyxia is death by deprivation of air. Death by anæsthesia is typically represented in death by chloroform; death by asphyxia is typically represented in drowning, or in immersion in carbonic acid gas.

When properly carried out, death by anæsthesia is by far the most certain and least violent of the two processes, although both are probably painless. The anæsthetic is as certainly proved to be painless as any such thing can be proved. In all but fatal accidents from chloroform in the human subject, we know, on the evidence of the persons who have passed through the ordeal, that there is no sense of suffering up to the extremest approach to death; and as we cannot suppose that the lower animals are more susceptible to pain than the highest animal, man, we must consider the death absolutely free of pain. An intense impression of sleep lapses into the sleep that is final.

It is worthy of record, however, that all animals are not equally susceptible to the action of the narcotic vapors. Cats, for instance, lie asleep much longer than dogs before they cease to breathe. They fall into sleep as rapidly as dogs, but do not pass so quickly into the final sleep. In the same narcotic atmosphere a cat will live twice as long as a dog, suffering nothing, and lying in deep sleep, but still breathing.

There is a difference between different animals of the same kind. Some dogs die almost instantly, in fact as they fall asleep; others fall asleep and continue to sleep for several minutes before they cease to live. In the first observations, before I had rendered the narcotic atmosphere overpoweringly active for all cases, there were a few instances, nine in the first seven hundred, in which the animals slept on from half an hour until an hour after all their comrades had died. Finding out this strange peculiarity, I increased the amount of narcotic vapor until all succumbed very nearly at the same minute, and in the last six thousand there has been no recurrence of the prolonged insensibility. The animals are now commonly all asleep in from two to three minutes, and have ceased to exist in a further period of the same duration. In order, however, to prevent any chance of recovery from the sleep on exposure to air too quickly, the instruction is that the chamber shall on no account be opened until the expiration of one hour after the introduction of the cage.

By introducing some other vapor into the lethal chamber with the chloroform, the vapor of hydrocyanic acid for instance, the death, no doubt, could be made more rapid, and indeed instantaneous. To this plan there are two objections, which are, I think, final. In the first place the death would be less peaceful; in the second place, the atmosphere produced would be extremely dangerous to the men employed. On the whole, we could not do better than continue in the course we have hitherto followed.

A SMALLER AND PORTABLE LETHAL CHAMBER.

The success of the trial on the large scale has led me to the construction of an apparatus on a small scale, an apparatus which can be moved easily from place to place, which can be kept at different parts of a city or town, at a police station, a veterinary surgeon's, or at any institution that will take it in charge. I entered on the construction of this machine some months ago, with the conviction that I could complete it in a few weeks, and have it ready for use at the Home in case where only one or two animals have to be destroyed. I am sorry to say that the road to success was not so easy. I have had, in fact, to construct no fewer than four chambers previous to getting in complete working form what I desired to secure.

The difficulties have arisen from three sets of circumstances. Firstly, that in a portable machine fitted for action at a few minutes' notice, it was not possible to have a fire or stove. Secondly, that in order to make the chamber adaptable to animals of different sizes, it was necessary to make it changeable in size. Thirdly, that the substance used for causing the anæsthetic death should be so cheap as to render the process generally applicable. I began by employing coal gas and chloroform, but here, again, was met by the danger of explosion. Then I proceeded to the study of the application of compressed carbonic oxide, which would answer well, but for the expense which would attach to this mode of applying it. Next, I passed to compressed gas with vapor of chloroform and carbon disulphide, but again found the cost too great. Lastly, I fixed entirely on the plan of surcharging common air with narcotic vapor by a bellows, or forcing pump, which answers exceedingly well.

In Fig. 5 there is shown a view of the portable lethal

FIG. 5.

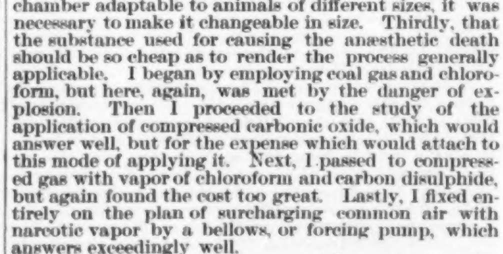


FIG. 5.—PORTABLE LETHAL CHAMBER.

chamber ready for use. It will be seen that the apparatus takes the shape of a closed truck on two wheels, and movable like a truck or barrow. It measures 5 feet in length, is 2 feet wide, and 2 feet 6 inches high. It moves very easily, and can be managed by one man. It is constructed, like the large lethal chamber, of well-seasoned wood, in double wall, with sawdust filling up the interspace. In Fig. 6 the apparatus is shown in section. As will be seen, there is one large chamber, having a capacity of nine cubic feet. The chamber opens at the top by a strong lid, swung from behind, which, when brought down, entirely closes up the chamber. Under this lid there is a frame with an opening in the center, through which baskets or cages of different sizes, and containing the animal or animals, can be let down into the larger space, and held there. This larger space is the narcotizing receptacle or chamber.

At the back of the apparatus is a recess in which is placed the narcotizing fluid, and the pump for forcing it into the cages containing the animals. The narcotic fluid is contained in a large strong Wolff's bottle filled loosely with Verity's fuel. The forcing pump is worked by a piston from the outside, and consists of a cylinder capable of containing one eighth of a cubic foot of air or gas. From the further end of the cylinder are two

tubes, one of which runs into the narcotizing chamber at the lower part, the other to the long tube in the Wolff's bottle below the surface of the narcotic fluid within the bottle. From the short or escape tube from the bottle is a continuous tube, terminating over the cage containing the animal. By an extra tap, coal-gas can, if desired, be let into this chamber.

MODE OF PROCEDURE.

The animal to be slept into death is placed, resting on a little straw or hay, in a cage, which is then dropped into the large receptacle, the lid of which is at once closed. The handle of the piston is then moved up and down at a regular and quiet pace. As the piston is drawn out, the cylinder of the pump is filled with air from the large receptacle, and as the piston is pushed back it forces the air with which the cylinder has been filled through the narcotic fluid, a portion of which it raises into vapor and forces into the cage. Eight strokes of the piston charge one cubic foot of air with the narcotic vapor to saturation, and as there are only nine cubic feet in all to charge, a couple of minutes are sufficient to charge throughout.

The animals in this apparatus pass quickly into sleep,

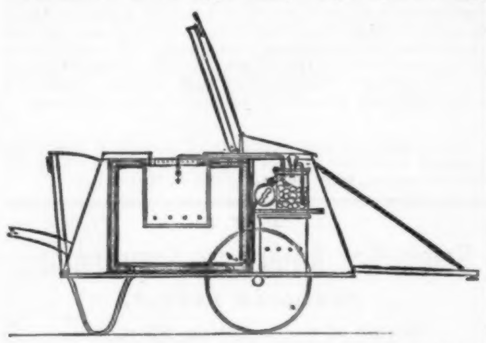


FIG. 6.—SECTION OF PORTABLE LETHAL CHAMBER.

and die not quite so quickly, but quite as painlessly, as in the larger structure.

This smaller apparatus will be so complete when it is finished, that it may be wheeled from the station to a private house, if that be wanted; or it may be used in the streets for giving painless death to wounded animals. It may also, in future, be constructed at so comparatively trifling a cost, that I see no reason why every town in the country may not be in possession of one, and every small animal be spirited away in sleep.

Compared with other modes of extinguishing animal life—such as hanging, drowning, poisoning by prussic acid, shooting, stunning—the lethal method stands far ahead on every ground of practical readiness, certainty, humanity. I cannot, however, let the opportunity pass of testifying that the method for twenty years carried out at the Dogs' Home, of killing with prussic acid, has been, by the skill and experience of the operators, brought to a great state of perfection and painlessness. The objections to it are moral and physical. It is a tax that few men can usually bear, to have every week to take scores of dogs one after another, and by force administer to each, singly, the deadly poison. Further the poison is so deadly I look upon it as almost a miracle that no man has been accidentally killed during the process.

LETHAL DEATH FOR ANIMALS TO BE USED AS FOOD.

It will be observed that hitherto I have dwelt only on the process of lethal death in its application to small domestic animals, such as dogs, cats, and birds. I am expected to add something more in reference to the painless destruction of those animals which supply us with food; but as the Society over which I have the honor to preside, the "London Model Abattoir Society," is about to build a model slaughter house, in which painless killing will form an important feature, it would be premature to enter into any details, until by careful trial the best methods have been secured. I may, nevertheless, be permitted to indicate that in respect to certain animals the painless death is quite feasible. By means of carbonic oxide, sheep can be put to sleep with the greatest rapidity before they are slaughtered. I have submitted forty sheep in this way to painless death, and found that no bad effect whatever is produced in the flesh unfitting it for food. The objection to retention of blood, so strongly felt by the Jewish people, does not obtain, the animals in the narcotic state yielding up blood just as freely as in the ordinary way, when no narcotic is used. The same process is equally applicable to swine, calves, and fowls. To oxen I do not as yet see its immediate application.

COMPARISON WITH OTHER MODES.

I have several times been asked whether there is any other method for the painless killing of animals intended for food which might be considered by the side of the lethal method. There is only one other mode which is really worthy of consideration, and that is the mode by the electric shock. The electric shock for this purpose was first proposed by the illustrious Benjamin Franklin, some twenty years after he had proved, by the famous kite experiment, the identity of the electrical and the lightning discharge. His suggestion is supplied in a letter, which he wrote, in 1773, to MM. Dubourg and D'Alibard, in the following terms:

"Having prepared a battery of six large glass jars (each from twenty to twenty-four pints), as for the Leyden experiment, and having established a communication, as usual, from the interior surface of each with the prime conductor, and having given them a full charge (which, with a good machine, may be executed in a few minutes, and may be estimated by an electrometer), a chain which communicates with the exterior of the jars must be wrapped round the thighs of the fowl; after which, the operator, holding it by the wings, turned back and made to touch behind, must raise it so high that the head may receive the first shock from the prime conductor. The animal dies instantly. Let the head be immediately cut off to make it bleed, when it may be plucked and dressed immediately. This quantity of electricity is supposed sufficient for a turkey of ten pounds weight, and perhaps for a lamb. Experience alone will inform us of the requisite proportions for animals of different forms and ages. Probably not less will be required to render a small bird, which is very old, tender, than for a larger one which is young. It is easy to furnish the requisite quantity of electricity, by employing a greater or less number of jars. As six jars, however, discharged at once, are capable of giving a very violent shock, the operator must be very circumspect, lest he should happen to make the experiment on his own flesh, instead of that of the fowl."

In pursuit of Franklin's idea, Mr. Collinson, an Englishman, a friend of his, endeavored to carry out the method in practice, in which attempt he himself received a shock, which told him that electricity was no respecter of animals. The experience put an end to the proposed method until the year 1869, when I revived it by means of the large induction coil then fitted up at the Royal Polytechnic Institution. I used in these inquiries twelve large Leyden jars, the whole representing ninety-six square feet of surface. In some cases the discharge was made in the ordinary direct way, in other instances the jars were set out in cascade, on the plan devised by Benjamin Franklin. The results, as many who saw them will remember, were most striking. It was proved that the shock in cascade was the most fatal, but by both methods small animals, rabbits and birds, were killed so instantaneously that they actually remained in the exact position they had assumed at the moment the shock was given, so that it required careful examination to prove that they were really dead. In these small animals the bodies were left after the shock in a state of complete rigidity; but in a short time the rigidity subsided, and the flesh ate tender. The common idea that after death from electrical shock rapid decomposition ensues was disproved, for in all cases the bodies of the animals remained for several days free from decomposition. In another series of experiments, larger animals, sheep, were subjected to the shock, and in every instance unconsciousness immediately followed the application of the shock, the current being passed from the heads of the animals through the body to the hind extremities. The method proved very difficult to carry out in practice, for two reasons. Firstly, it was found that if the shock were so decisive that death took place absolutely, the animal would not afterward bleed, while, if the shock were not completely decisive, the animal, during the flow of blood, evinced certain signs of returning consciousness, a phenomenon as remarkable as it was unexpected. Secondly, it was found as in Mr. Collinson's experiments that the administration of the shock would be dangerous to the operators, unless they took more care than could be expected from the men who are employed in the duties of the slaughter-house.

I do not despair altogether of making electricity practically useful for the extinction of life of some of the larger animals, such as horses and oxen. I have in view the construction of a porch through which a large animal may be conveyed on a truck, and during the passage through which and in no other position may receive the fatal shock. But at present the expense connected with the carrying out of this suggestion would in itself be a barrier to success.

CONCLUDING NOTE ON EXPENDITURE CONNECTED WITH THE LETHAL PROCESS.

The use of the word expense leads me, finally, to refer to a question which has been asked of me from various parts of the kingdom, relative to the expense of setting up the lethal apparatus.

In what has been done up to the present time, so much has, of necessity, been experimental, it would not be fair to calculate the expenditure connected with these first efforts as a guide to what would be the cost of a new apparatus made from the completed design. Roundly, I may say that the prime cost of the large chamber and cage, for material and labor exclusively, was, in the first instance, about £145. Since then, another cage and another stove have been added, together with iron lines, now being fitted, and with various alterations which have increased the expense. I think, however, that such a chamber, starting afresh, with all the details now understood, could be constructed for, from £150, to £175. The smaller chamber has cost, in the original working out, a larger sum in proportion, owing to the difficulties of adapting it to all requirements demanded, and the frequent reconstructions. Now, however, that it is brought into practical form, a new design from it may, I think, be constructed for £50, and if there were a demand, for even less.

The cost of charcoal for the stoves with the addition of anæsthetic fluid is, in the large chamber, a little over one-half penny per animal when eighty to a hundred are killed at one time. When fewer are killed the expense is a little increased; the trouble and substance required being as little for a hundred as for a less part of that number.

The cost of working the little chamber is not so easily reckoned, inasmuch as the labor for moving it from one place to another will vary, while the anæsthetic required for destroying one animal would be nearly the same as for six or eight introduced at once. In any place where the small chamber is retained as a fixture, and where it is kept carefully closed, it will at all times be charged with anæsthetic vapor, and be very little more expense than the larger apparatus.

I bring my lecture to a close with the reflection that science, sometimes considered hard and unrelenting, has in this case another and different feature. If she sometimes, for the sake of man, inflicts pain on the lower creation, here she relents and does for the lower creation what she dare not do for man. By comparison, the boon is enormous. Except for the corporeal suffering, the dumb animal seems to have no pain in the prospect of death, while to man, "The sense of death is most in apprehension," and to most men is so even more acutely than the act itself. Thus he who wrote the burial service expressed the most universal of desires that at our last hour no pains of death may fall. Perchance for himself and his own kin, man, with all his ingenuity, will never see his way to escape that desire, until by a better life he wins the death by natural sleep, which nature has ordained to be as painless as his birth. Grateful, nevertheless, may he be that the power is in his hands of giving to his inferior earthmates what he himself most earnestly prays for, Euthanasia.

PROGRESS IN PROVISION FOR THE INSANE, 1844-1884.

WE abstract the following from an interesting paper by W. W. Godding, M.D., Superintendent of the Government Hospital for the Insane, Washington, D. C., read at the Annual Meeting of the Association of Superintendents of American Institutions for the Insane, held at Philadelphia, Pa., May 13, 1884, as a part of the Memorial Exercises of the Fortieth Anniversary of the Association.

One of the old thirteen who held that first meeting is here to preside to-day.* Dr. Butler, of Hartford, Conn., Dr. Stokes, of Baltimore, Md., and Dr. Chandler, of Worcester, are the only other men living who were superintendents of institutions for the insane in America in 1844.

At this time there were of institutions for the insane twenty-five in all, of which thirteen only were distinctly State hospitals, having in 1844 a population of about fifteen hundred insane, out of some seventeen thousand in the country; the insane being then estimated at one to every thousand inhabitants. As one year later the number of the insane in these hospitals had risen to more than two thousand, it is probably safe to estimate their capacity as fully twenty-five hundred. But even placing the accommodations afforded by these twenty-five State, private, and corporate establishments as high as three thousand, which would certainly be their limit, there would still remain more than four-fifths of the insane to be provided for in almshouses, in jails, in cages, or adrift at large in the community. This was the provision for the insane in 1844.

In 1884 I find that the institutions of all kinds for the care of the insane in America have increased more than five-fold since 1844, but in the mean time the ratio of the insane to the whole population has risen from one in every thousand then to one in every five hundred now, so that to-day there is probably not less than one hundred thousand insane within the limits of the United States. The increased provision will probably afford good accommodation for thirty thousand inmates, and at the date of the United States census in 1880, forty thousand nine hundred and forty-two were crowded into these hospitals, including the insane departments of alms-houses, leaving the majority still to be provided for, as in 1844, indiscriminately huddled in alms-houses, in jails, in cages, and adrift in the community. Thus far only, then, have we come with our progress in provision in forty years.

TANEKAHA BARK OF NEW ZEALAND.

CONSUL GRIFFIN, of Auckland, states that the tanekaha bark is a product peculiar to New Zealand, and is found in no other country in the world. During the last few years large quantities have been exported to Europe, where it is highly prized on account of its superior dyeing and tanning properties. Recent tests have established the fact that it is one of the best vegetable dyes in the world, and especially for yellow, pink, and fawn colors. The tree producing the bark belongs to the genus *Phyllocladus*, comprising the trees known as the "celery-leaved pines." It belongs to the same section of the conifers as the well-known yew of Europe and North America, although it differs widely from it in habit and appearance. Only five species of the genus *Phyllocladus* are known to exist. Three of these are peculiar to New Zealand, one is a native of Tasmania, and the other inhabits the mountains of the island of Borneo. The New Zealand species are as follows: The *Phyllocladus trichomanoides*, known as the tanekaha of the Maoris; the *Phyllocladus glauca*, or *toa toa*; and the *Phyllocladus alpina*, or mountain tanekaha. The two species found out of New Zealand are but little known, and are not applied to any economic purpose. The Tasmanian plant, the *Phyllocladus rhomboidalis*, is found in the hilly parts of the island, and grows to a height of forty or fifty feet. The Borneo species is called *Phyllocladus hypophylla*, and rarely attains a greater height than twenty feet. The New Zealand tanekaha at its full growth is from sixty to seventy feet high, and the trunk is about three feet in diameter. The timber from the tree is remarkable for its strength and durability; it is very close in the grain, and is of a reddish-white color. The tree has a peculiar appearance. It throws out its small thin branches with great regularity, almost at right angles with the trunk. The foliage consists of coriaceous, obovate, toothed phyllodia, so nearly like leaves that they are often mistaken for them; in fact, the so-called leaves of the tanekaha tree are composed of the flattened and expanded small branches of the tree growing together. The actual leaves are seen only on the seedling plant, and are linear and sharply pointed, but they soon drop off, and their places are taken by the small branches, which are expanded horizontally and are variously lobed. An interesting fact connected with the tanekaha tree is that it makes a most beautiful walking-stick. The bushmen bruise the bark of the sapling at regular intervals, and after a few days cut the sapling down and peel off the bark. The stick then presents a mottled surface, and of a permanent bright red and white color. In obtaining the bark of the tanekaha for exportation, the following is the method employed: The tree is stripped of its bark by making a transverse incision with a knife round the trunk at the bottom, and a similar cut just below the junction of the branches. Vertical incisions are then made with a very sharp knife, and the bark removed in long narrow strips, and all the branches large enough to contain bark of any value are stripped in the same manner. The tree, if not too large, is generally cut down, and the bark removed more easily, it being useless to endeavor to save the tree, as removing the bark invariably kills it. The tannin is deposited by the sap principally in the inner portion of the outer bark and the outer portion of the inner bark, or liber. In New Zealand the bark is usually gathered in the winter, but Consul Griffin states that it is preferable to undertake this work in the spring, as the tannin is most abundant at the time of the greater flow of sap which always occurs at this season. The bark, when peeled, is put up in bundles

* Dr. Pliny Earle, of Northampton, Mass., President of the Association. The Association was organized at Philadelphia, Pa., in October, 1844; present, Drs. Samuel B. Woodward, Luther V. Bell, C. H. Stedman, and Dr. N. Cutter, of Massachusetts; Dr. Isaac Ray, of Maine; Dr. John S. Butler, of Connecticut; Drs. Amariah Brigham, Samuel White, and Pliny Earle, of New York; Dr. Thomas S. Kirkbride, of Pennsylvania; Dr. William M. Awl, of Ohio; and Dr. Francis T. Stribling and Dr. John M. Galt, of Virginia. Of these only Drs. Butler and Earle survive.

from 4 ft. to 5 ft. in length, and is then ready for shipment, usually to London, whence it finds its way to Grenoble, where it is largely used for the purpose of coloring kid gloves. It is only of late years that tanekaha bark has been exported from New Zealand, and owing to its valuable properties it is expected that the trade in this article will largely increase; in 1873, the amount exported was 24 tons, while during the first six months of 1883, the latest date for which returns are available, it exceeded 575 tons, with a value of £4,000.—*Journal Soc. Arts.*

THE KOLA-NUT.

The recent discovery of the anæsthetic action of cocaine has led several investigators to examine the therapeutic effects of certain allied substances which have been known to be used for assuaging hunger and for bearing protracted fatigue. The principal one of these is caffeine (in coffee or tea); others are guaranine and theobromine. It has, however, been ascertained, at least in the case of caffeine, that it does not share the peculiar property of cocaine of acting as a local anæsthetic, but, on the contrary, is a local irritant. Nevertheless, experiments are being continued with the various drugs yielding these principles, and among them the kola-nut has attracted attention because it has long been known to be used, by the natives in a portion of Western Africa, for precisely the same purposes as coca is used by the mountaineers of the Andes. We have received a number of inquiries on the subject, and though we have once published an account of the plant yielding the kola-nut (*New Rem.*, 1881, p. 34), we think it will interest many of our readers if we supplement the information, there given, by some further details which we take from a paper by H. Zohlenhofer (in *Arch. d. Pharm.*, 222, 334).

Palisot-Beauvois, in his Flore d'Oware, relates that the negroes of Oware eat the kola-nuts chiefly because they have the remarkable property, after having been chewed, of imparting a pleasant taste to all subsequent food or drink, particularly to water. The effect lasts only while the interior of the mouth is lined with the magma.

The fresh seeds of the kola are much more bitter than the dry, which is probably owing to the loss of some volatile principle lost on drying. This explains why the negroes do not care for the dried seeds, but always prefer them fresh.

Prax (in "Commerce de l'Algérie avec la Mecque et le Soudan," Paris, 1849, p. 19) says:

The merchants first strip the seeds completely from the envelope, and wrap them afterward in large leaves taken from various Sterculiaceæ (to which family the kola-nut belongs). They are then packed in large baskets, called *uagha*, which are formed in this manner: four pieces of flexible wood are tied together crosswise, so that each two of them have the shape of a horseshoe, and this frame is covered with a piece of tanned ox-hide. The basket being filled with the seeds, a four-times folded sack gherara is laid on top and tied to the four pieces of wood.

Every month the seeds are washed with fresh water, and covered with new leaves; in this way they are said to keep for eight or ten months.

Heckel and Schlagdenhauffen have found the seeds to contain 2·35% of caffeine and 0·02% of theobromine.

The fruit of the kola-tree (*Sterculia acuminata* Sch. and Endl.) consists of a chestnut-brown pericarp, covered with a dry skin, and inclosing two to ten seeds. It has (at least the specimen accessible to Mr. Zohlenhofer had) about the shape of a flattened egg, is nine cm. long, five cm. broad, and three cm. high. At one end is seen the place where the stalk has been broken off, the other ends in a short beak.

The fresh seed consist of two to three cotyledons, externally purple and internally rose-color to bright purple. The edges of the cotyledons appear slightly swollen. The size of the cotyledons varies greatly; sometimes one is so small that it lies in a cavity inside another. The whole surface is traversed by fine wrinkles, which disappear, however, completely on drying. The embryo is anatropous and comparatively small. In consistence, the seed may be compared to that of a chestnut. The taste is similar to that of the coffee-bean.

Zohlenhofer's experiments confirm the statement made by others that the chewing of the seed makes drinking-water, even when comparatively impure or stale, quite palatable.—*Amer. Druggist.*

THE COLA NUT FROM WHICH COCAINE IS MADE.

CULTIVATION OF THE COCA PLANT IN THE UNITED STATES.

In view of the undoubted importance and value of the alkaloid cocaine as a local anæsthetic, it is fair to presume that the supply of coca from its native home, in the Eastern Andes of Bolivia, Peru, and Ecuador, which is estimated at about thirty-five millions of pounds annually, will be insufficient to satisfy the demand. The by far greatest portion of this quantity is consumed at home, and only a comparatively small portion has heretofore been exported. But as coca yields never over one-fourth of one per cent. and is said to yield sometimes only one-sixtieth of one per cent. of cocaine, it is easy to see that it requires a very large amount of crude material to produce the quantities of alkaloid likely to be required.

If ever there was an argument in favor of manufacturing an article of this kind in its native country, such an argument is supplied in the case of coca.

Coca leaves occupy a considerable bulk, and are moreover liable to deterioration by long keeping, bad stowage during the sea-voyage, etc. If an enterprising firm were to locate proper works in a suitable place in South America, as close to the main source of supply as possible and with easy facilities for export, large amounts of crude cocaine, or at least an extract of coca, could be manufactured on the spot which might be forwarded to this and other countries for further purification. The great saving of expense in freight and the enriched quality of the extract or crude alkaloid, owing to the fresher raw material employed, would no doubt far overbalance the first expense of the undertaking and the cost of shipment, together with any custom duties and the further cost of purification.

Another means of obtaining the crude material with more facility would be to cultivate the coca plant in this country. Probably, however, there will be met with the same difficulty as has been encountered when attempting to cultivate cinchona. Coca flourishes in its home at altitudes between five thousand and six thousand feet above the level of the sea, and is chiefly found in the warm valleys of the *eastern* slopes of the Andes, where almost the only variation of climate is from wet to dry, *where frost is unknown*, and where it rains more or less every month of the year. If such a locality can be found in the United States, it will be of the highest importance to try the cultivation. Should no such place be discovered in this country, it is highly probable that Mexico will offer numerous suitable localities.

ASH OF VEGETABLE LIQUIDS.

M. Jay, the author, dries at 110 degrees the extract obtained in a platinum capsule from 20 c. c. of wine. He ignites slightly so as to obtain a charred mass, but not ash. He then adds a few drops of water, and places it on the water-bath. The water acts upon the carbon in such a manner that it falls to a powder spontaneously, while the alkaline salts leave it and deposit themselves on the sides of the capsule. The desiccation is then finished at 110 degrees to 115 degrees, and the residue ignited. The author thus quickly obtains a very white ash without any loss of the alkaline salts.

A catalogue containing brief notices of many important scientific papers heretofore published in the Supplement, may be had gratis at this office.

THE

Scientific American Supplement.

PUBLISHED WEEKLY.

Terms of Subscription, $5 a year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of The Supplement, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of The Supplement can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

Combined Rates.—One copy of Scientific American and one copy of Scientific American Supplement, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,
361 Broadway, New York, N. Y.

TABLE OF CONTENTS.